Montana Water Use in 1980

March 1986

MONTANA WATER USE IN 1980

Montana Department of Natural Resources and Conservation

Water Resources Division

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Gerhard Knudsen
Steve Holnbeck
Wayne Wetzel
Doug Oellermann
Rich Brasch
Art Taylor
Darby Fuerst

Information and Assistance

Tim Flannagan
Jerry Edwards

Data and Word Processing, Editing, and Layout

George Cawlfield
Jack Zanto
Margie Peterson
Julie Frickel
Melissa Otis
Lindy Proue
Debbie Waples
Lee Shelton
Don Howard
June Virag
Peggy Todd
Carole Massman

ABSTRACT

The National Water Use Data System (NWUDS) is a cooperative program of the United States Geological Survey (USGS) and the Montana Department of Natural Resources and Conservation (DNRC). Information on water use is collected through the data system, and this publication reports 1980 estimates for Montana. Seven kinds of water use were estimated: municipal, hydroelectric power generation, thermoelectric power generation, self-supplied industrial, rural domestic, livestock, and irrigation. Evaporative loss of water from reservoirs was also estimated.

Table 1 summarizes the results of this report for off-stream water uses.

TABLE 1. WATER WITHDRAWN AND CONSUMED IN MONTANA IN 1980

Use	Water Withdrawn (acre-feet)	Water Consumed (acre-feet)
Irrigation	15,044,000	3,251,000
Municipal	157,000	58,000
Rural domestic	16,000	16,000
Self-supplied industry	62,000	9,000
Livestock	28,000	28,000
Thermoelectric power generation	107,000	9,000
TOTAL	15,414,000	3,371,000

In addition to the off-stream uses shown in table 1, 73,984,000 acre-feet of water was used to generate hydroelectricity. After powering the turbines, this water was returned to the stream for reuse. Reservoir evaporation also accounted for a loss of 3,925,000 acre-feet of water in Montana river basins.

INTRODUCTION

Water is essential for life. Water can mean granaries full of wheat, grass for cattle and wildlife, power for electrical generation, and quality fishing. In an average year, almost 44 million acre-feet of water flow out of Montana. Of this amount, 65 percent originates within the state. To ensure there will be enough water to meet Montana's current and future needs, water must be managed wisely. Wise management requires reliable information on supply and use. Without good data, planners may not make sound decisions on issues that could affect the availability and quality of the state's water.

This report records estimates of water use in Montana during 1980. These estimates were based on data collected through the National Water Use Data System (NWUDS), a cooperative program between the U.S. Geological Survey (USGS) and the Montana Department of Natural Resources and Conservation (DNRC). NWUDS is designed to collect, store, and disseminate information on water use.

In this report water use and loss are divided into three categories: off-stream use, in-stream use, and reservoir evaporation. Off-stream use is the withdrawal or diversion of water from a ground or surface source for irrigation, municipal use, rural domestic use, self-supplied industrial use, livestock use, and thermoelectric power generation. The second category, in-stream use, is use of water in stream channels to generate hydroelectricity. The third category, reservoir evaporation, is the loss of water into the atmosphere from man-made impoundments. Except for water used to generate hydroelectricity, in-stream flows are not considered in this report due to a lack of consistent, statewide data. Nevertheless, in-stream flows are important in Montana for sustaining fish and wildlife populations, water quality, stream channel morphology, and recreational opportunities.

Water use can be estimated as either the water withdrawn or the water consumed for a particular purpose. Water withdrawn is that water removed from the ground or diverted from a surface source (USGS 1980). Consumed water is

that water no longer available for use, because it has evaporated, transpired, or been used in the production of crops, livestock, or manufactured goods (USGS 1980). This report contains estimates of the amount of water withdrawn and consumed for each use in each Montana county. Figure 1 is included to familiarize the reader with the location of each county. Appendix A lists water use estimates by USGS hydrologic unit. Estimates of water withdrawn and consumed are also separated by source. Source refers to where users obtain water, either from the surface or the ground.

Water for municipal systems may also be purchased. Though purchased water can be from either surface or ground sources, it was considered a separate source in this report, which is consistent with the NWUDS program format.

Water use is measured in acre-feet (af) throughout this report. An acre-foot is the quantity of water that covers one acre to a depth of one foot: 325,851 gallons. All water use data in the county and hydrologic unit summaries are rounded to the nearest acre-foot. Rounding to the nearest acre-foot was done to maintain consistency among the data tables and to account for small amounts of water where rounding to larger units would have resulted in an insignificant estimate of use in some categories.

Several problems made determining water use in Montana difficult. The amount of water withdrawn from rivers, streams, and the ground varies from year to year and season to season. The weather and market conditions influence the amount of water used in any given year. In addition, measured data are often lacking, and water use has to be estimated. Appendix B explains the methods and information sources used to estimate water use for each category.

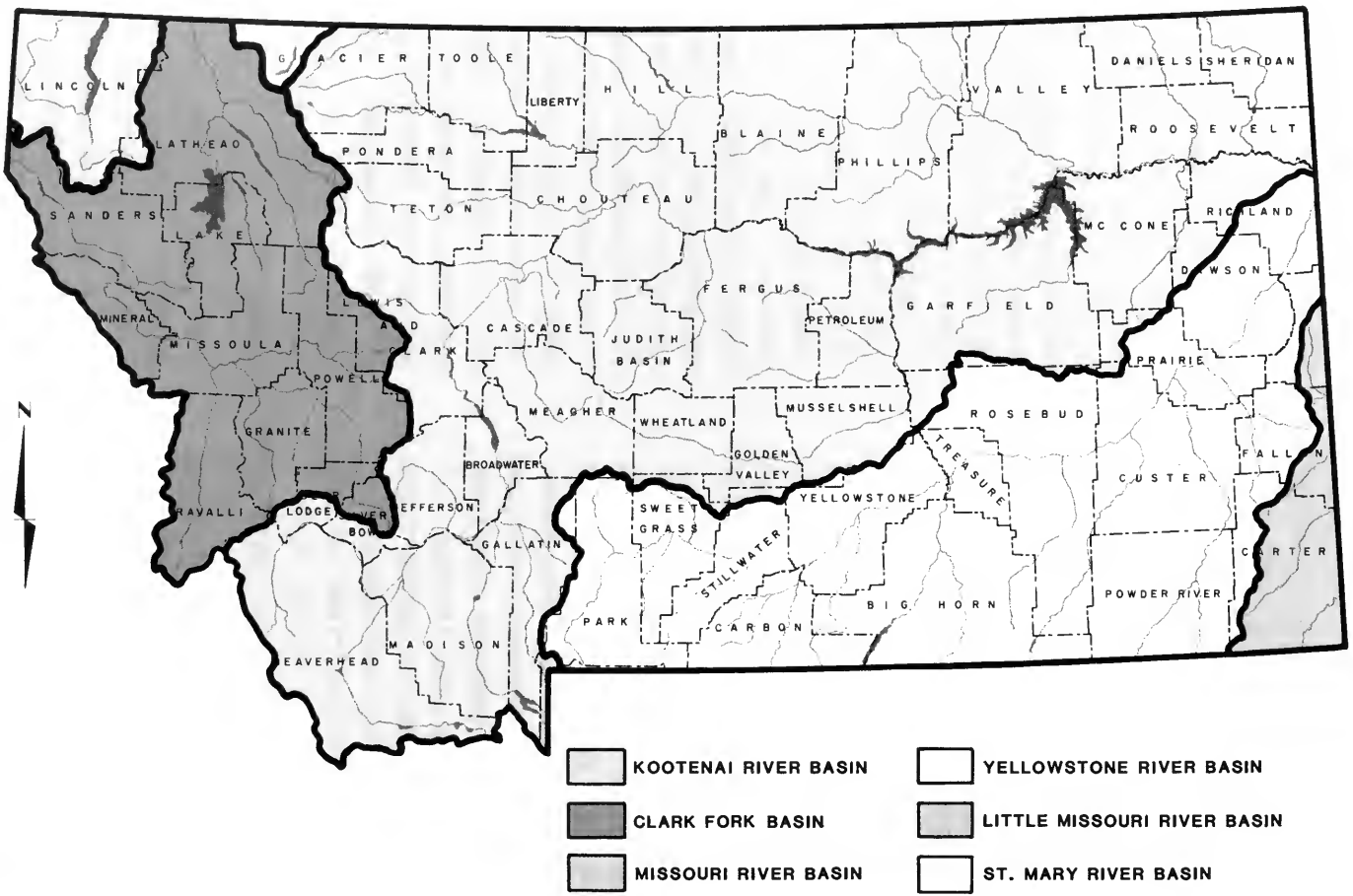
OFF-STREAM USES

IRRIGATION

Irrigation sustains agriculture by supplementing rain and snowmelt. Montana's irrigated crops include alfalfa, wheat, barley, oats, other small grains, sugar beets, grass, corn, and cherries.

Both full-service and partial-service irrigation methods are employed in Montana. Full-service irrigation provides the

FIGURE 1 – COUNTIES AND MAJOR RIVER BASINS



entire irrigation water requirements of a crop through the delivery of surface or ground water, and includes both flood and sprinkler systems. In this report, partial service irrigation refers to water spreading, which is the diversion of streamwater during periods of high flow to flood irrigate nearby lands. Such flows are generally available for only one application per year.

Table 2 summarizes 1980 water use estimates for irrigation in Montana. Irrigators withdrew approximately 15,044,000 af of water, and consumed 3,251,000 af. The greatest withdrawal of irrigation water occurred in Beaverhead County, where 1,279,000 af was used to irrigate 277,000 acres. The next largest withdrawal occurred in Carbon County, where 1,212,000 af was used to irrigate 158,000 acres.

MUNICIPAL

Municipal water supply systems deliver water for domestic, industrial, and other general public purposes. Municipal water needs may be supplied from both surface and ground water, and sometimes is purchased from another supply system. Municipal systems supply water to about 75 percent of Montana's population.

Table 3 summarizes municipal water use. It includes census figures on the population served, and estimates of the amount of water withdrawn and consumed. It also includes estimated average water consumption per person in gallons per day (gpd). During 1980, the following counties had the greatest municipal water withdrawals: Missoula (27,000 af), Yellowstone (23,000 af), Cascade (16,000 af), and Silver Bow (14,000 af).

RURAL DOMESTIC

Rural domestic refers to the residential use of water in areas that are not served by municipal systems. Generally this category applies only to isolated rural homes. However, the incorporated towns of Lavina, Drummond, Terry, Outlook, and Walkerville are also included because each household in these towns depends on its own supply system.

A summary of rural domestic water use is presented in table 4. A total population of 199,000 consumed approximately 16,000 af of water. The greatest rural domestic withdrawals occurred in Missoula (1,500 af) and Ravalli (1,300 af) counties.

SELF-SUPPLIED INDUSTRY

Self-supplied industrial water refers to water delivered by supply systems that are owned by individual industries. This category does not include industries that obtain water from municipal systems. Petroleum refining, chemical manufacturing, wood products manufacturing, sugar refining, and mining are the major water-using, self-supplied industries in Montana.

Estimates of water withdrawn and consumed for self-supplied industry by county are presented in table 5. Of the 62,000 af withdrawn for self-supplied industries, it is estimated that 9,000 af of water was consumed. The greatest water withdrawals for self-supplied industry took place in Missoula (23,000 af) and Lincoln (15,000 af) counties. Most of this water was used for wood product manufacturing and minerals processing. Large amounts of water were also withdrawn in Mineral, Silver Bow, Flathead, and Yellowstone counties, and were used for petroleum and sugar refining, and chemical and wood products manufacturing.

LIVESTOCK

Livestock water is that used by cattle, sheep, hogs, and chickens. For this report, all water withdrawn for livestock is considered consumed (DNRC 1975).

Table 6 summarizes the amount of water consumed by livestock in each county. Montana livestock consumed approximately 27,500 af of water. Livestock water use was greatest in Beaverhead (1,600 af) and Fergus (1,300 af) counties.

THERMOELECTRIC POWER GENERATION

This category includes the use of water for cooling thermoelectric generators, and that used incidentally in the operation of these facilities. Table 7 summarizes water use by thermoelectric generators in each county. Approximately 107,000 af of water were used to generate 6 million megawatt hours (MWh) of electricity. Thermoelectric generation used only surface water. Most use occurred in Yellowstone (53,000 af) and Richland (34,000 af) counties. Figure 2 shows the estimated water use of power plants within each county in 1980.

TABLE 2. SUMMARY OF IRRIGATION WATER USE BY COUNTY IN 1980*

County	Lands Irrigated By Ground Water (acres)	Lands Irrigated By Surface Water (acres)[1]	Water Withdrawn Ground Water (af)	Water Withdrawn Surface Water (af)	Water Withdrawn All Sources (af)	Water Consumed Ground Water (af)	Water Consumed Surface Water (af)	Water Consumed All Sources (af)[2]
Beaverhead	1,108	275,874	1,318	1,277,732	1,279,050	975	242,796	243,771
Big Horn	3,986	65,851	7,272	423,328	431,692	5,381	88,899	94,717
		(1,344)		(1,092)			(437)	
Blaine	5,102	82,869	9,583	479,950	489,533	7,092	115,188	122,280
Broadwater	1,006	58,153	1,550	331,472	333,022	1,147	66,294	67,441
Carbon	791	157,528	1,315	1,210,996	1,212,311	973	193,759	194,732
Carter	2,254	2,742	4,447	9,310	68,655	3,291	4,003	39,135
		(42,970)		(54,898)			(31,841)	
Cascade	557	42,609	941	213,045	227,144	696	53,261	59,220
		(7,519)		(13,158)			(5,263)	
Chouteau	628	8,296	1,230	54,678	64,529	911	12,029	16,388
		(6,788)		(8,621)			(3,448)	
Custer	737	26,983	1,414	136,842	164,368	1,046	38,316	55,551
		(24,907)		(26,112)			(16,189)	
Daniels	3,044	1,090	6,376	6,257	15,517	4,718	1,689	8,080
		(2,542)		(2,884)			(1,673)	
Dawson	45	18,385	90	100,777	105,388	67	27,210	30,080
		(4,312)		(4,521)			(2,803)	
Deer Lodge	88	22,041	88	102,858	102,946	86	21,600	21,686
Fallon	517	148	1,118	493	5,417	872	237	3,469
		(3,543)		(3,806)			(2,360)	
Fergus	1,293	19,102	2,499	136,579	143,327	1,849	27,316	31,629
		(4,481)		(4,249)			(2,464)	
Flathead	6,576	32,104	10,130	69,054	79,184	7,497	36,598	44,095
Gallatin	6,894	133,794	9,968	681,712	691,680	7,376	143,159	150,535
Garfield	732	1,212	1,652	5,326	23,514	1,222	2,024	11,514
		(10,908)		(16,536)			(8,268)	
Glacier	1,584	17,818	1,670	81,753	89,712	1,235	13,898	17,648
		(8,385)		(6,289)			(2,515)	
Golden Valley	0	11,105	0	88,840	90,636	0	15,103	15,821
		(2,274)		(1,796)			(718)	
Granite	527	37,095	669	145,289	145,958	495	34,869	35,364
Hill	2,124	5,631	4,162	34,021	44,679	3,080	8,165	13,843
		(5,197)		(6,496)			(2,598)	
Jefferson	561	39,526	902	223,981	224,883	667	47,036	47,703
Judith Basin	581	15,187	1,052	156,543	162,395	778	20,350	23,912
		(4,283)		(4,800)			(2,784)	
Lake	1,822	112,060	3,127	547,370	550,497	2,314	142,316	144,630
Lewis & Clark	6,906	50,647	11,199	276,254	287,453	8,287	60,776	69,063
Liberty	0	3,724	0	25,882	30,092	0	5,176	6,860
		(3,437)		(4,210)			(1,684)	
Lincoln	166	8,577	296	37,739	38,035	219	11,322	11,541
Madison	417	138,775	592	910,711	911,303	438	145,714	146,152
McCone	0	5,515	0	20,136	32,356	0	8,658	15,746
		(11,197)		(12,220)			(7,088)	
Meagher	0	56,532	0	429,643	429,643	0	64,446	64,446
Mineral	76	2,544	147	8,662	8,809	109	3,638	3,747
Missoula	2,414	34,168	3,849	134,394	138,243	2,848	40,318	43,166
Musselshell	118	16,034	268	149,651	150,587	198	26,937	27,402
		(668)		(668)			(267)	
Park	1,967	68,269	3,269	524,818	528,087	2,419	83,971	86,390
Petroleum	320	11,900	696	83,300	89,118	515	19,159	22,644
		(4,627)		(5,122)			(2,970)	
Phillips	3,661	76,935	7,223	534,881	559,764	5,345	112,325	127,913
		(15,758)		(17,660)			(10,243)	
Pondera	3,699	82,188	5,248	359,572	421,568	3,884	86,297	112,880
		(46,231)		(56,748)			(22,699)	
Powder River	310	7,314	662	24,587	59,894	490	11,556	30,755
		(31,181)		(34,645)			(18,709)	
Powell	468	66,333	569	284,284	284,853	421	59,700	60,121
Prairie	1,029	8,581	2,016	59,250	68,700	1,492	12,442	18,246
		(6,474)		(7,434)			(4,312)	
Ravalli	1,275	105,005	2,102	457,522	459,624	1,555	128,106	129,661
Richland	635	44,392	1,364	441,145	446,556	1,010	70,583	74,102
		(3,860)		(4,047)			(2,509)	
Roosevelt	759	10,161	1,518	71,611	84,359	1,123	15,038	22,674
		(10,161)		(11,230)			(6,513)	
Rosebud	1,062	33,024	1,765	184,634	191,895	1,306	40,619	44,123
		(6,764)		(5,496)			(2,198)	
Sanders	2,156	30,019	4,166	186,640	190,806	3,083	42,927	46,010
Sheridan	8,078	(2,779)	16,374	(3,033)	19,407	12,117	(1,759)	13,876
Silver Bow	45	7,389	53	26,009	26,062	40	6,502	6,542

[1]Figures in parentheses refer to partial service irrigation.
[2]Includes partial service irrigation.

Table 2 (cont'd.)

County	Lands Irrigated By: Ground Water (acres)	Lands Irrigated By: Surface Water (acres)[1]	Water Withdrawn: Ground Water (af)	Water Withdrawn: Surface Water (af)	Water Withdrawn: All Sources (af)	Water Consumed: Ground Water (af)	Water Consumed: Surface Water (af)	Water Consumed: All Sources (af)[2]
Stillwater	428	34,914 (353)	729	244,398 (353)	245,480	539	43,992 (141)	44,672
Sweet Grass	178	58,155 (1,187)	334	538,903 (938)	540,175	247	80,835 (375)	81,457
Teton	733	126,870 (18,958)	1,070	721,156 (17,773)	739,999	792	137,030 (7,109)	144,931
Toole	9	2,788 (5,924)	16	14,721 (7,405)	22,142	12	3,680 (2,962)	6,654
Treasure	790	22,918 (231)	1,527	142,490 (231)	144,248	1,130	32,773 (92)	33,995
Valley	3,699	45,482 (27,876)	7,248	274,787 (30,808)	312,843	5,363	65,949 (17,868)	89,180
Wheatland	1,882	30,199 (934)	3,128	265,320 (777)	269,225	2,315	37,145 (311)	39,771
Wibaux	0	32 (754)	0	135 (821)	956	0	51 (427)	478
Yellowstone	3,031	100,489 (1,015)	5,243	559,243 (929)	565,415	3,880	128,626 (371)	132,877
TOTAL	88,868	2,806,898	155,244	14,888,490	15,043,734	114,945	3,136,374	3,251,319

[1]Figures in parentheses refer to partial service irrigation.
[2]Includes partial service irrigation.

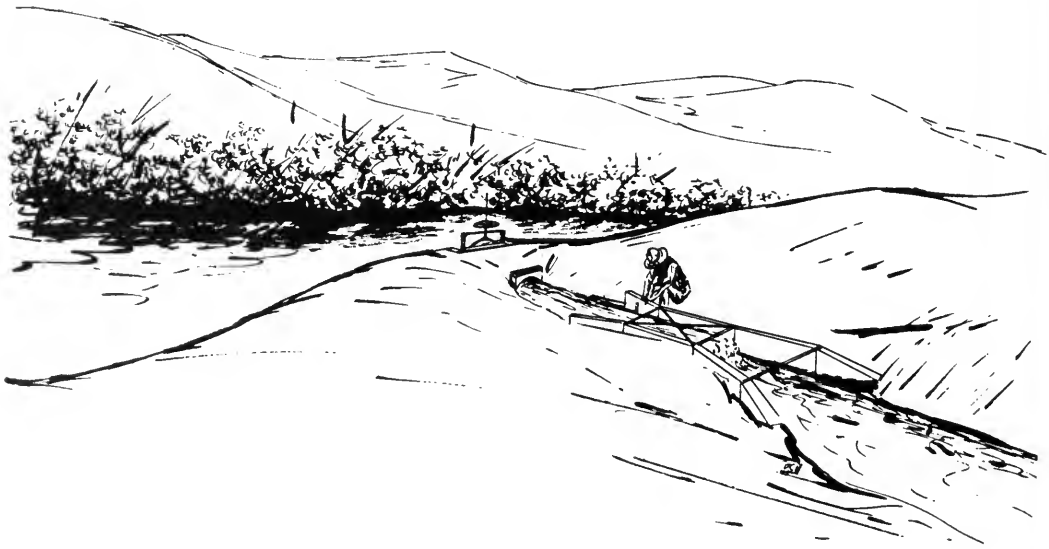


TABLE 3. SUMMARY OF MUNICIPAL WATER USE BY COUNTY IN 1980

County	Population Served	Per Capita Use (gpd)	Water Withdrawn: Ground Water (af)	Water Withdrawn: Surface Water (af)	Water Withdrawn: Purchased Water (af)[1]	Water Withdrawn: All Sources (af)	Water Consumed: All Sources (af)[2]
Beaverhead	4,294	386	591	1,271	0	1,862	689
Big Horn	5,271	178	314	741	0	1,055	390
Blaine	3,127	178	46	579	0	625	231
Broadwater	1,736	561	1,094	0	0	1,094	405
Carbon	4,442	319	663	929	0	1,592	589
Carter	628	132	93	0	0	93	34
Cascade	80,192	182	957	14,116	1,327	16,400	6,068
Chouteau	3,669	300	333	903	0	1,236	457
Custer	12,310	128	231	1,542	0	1,773	656
Daniels	1,540	168	291	0	0	291	108
Dawson	9,155	223	421	1876	0	2,297	850
Deer Lodge	9,675	441	4,660	129	0	4,789	1,772
Fallon	2,534	167	475	0	0	475	176
Fergus	8,459	254	2,406	8	0	2,414	893
Flathead	37,805	154	4,316	2,163	73	6,552	2,424
Gallatin	30,573	246	2,164	6,269	0	8,433	3,120
Garfield	500	119	67	0	0	67	25
Glacier	7,197	226	1,002	784	37	1,823	674
Golden Valley	385	250	17	91	0	108	40
Granite	1,099	43	0	53	0	53	20
Hill	16,695	125	1,194	1,137	6	2,337	864
Jefferson	3,546	473	1,882	0	0	1,882	696
Judith Basin	712	93	74	0	0	74	27
Lake	10,037	140	749	825	0	1,574	582
Lewis & Clark	31,414	238	1,768	6,627	0	8,395	3,106
Liberty	1,305	250	11	356	0	367	136
Lincoln	9,783	150	882	760	6	1,648	609
McCone	990	127	141	0	0	141	52
Madison	2,225	157	215	176	0	391	145
Meagher	1,665	206	77	307	0	384	142
Mineral	1,925	180	390	0	0	390	144
Missoula	58,777	409	14,882	12,096	0	26,978	9,982
Musselshell	2,684	356	1,031	43	0	1,074	397
Park	10,401	255	2,866	109	0	2,975	1,100
Petroleum	250	64	18	0	0	18	7
Phillips	2,934	142	442	26	0	468	173
Pondera	3,251	181	138	522	0	660	244
Powder River	1,080	232	282	0	0	282	104
Powell	4,153	270	1,259	0	0	1,259	466
Prairie	0	0	0	0	0	0	0
Ravalli	7,377	456	2,381	1,399	0	3,780	1,398
Richland	8,179	179	1,648	0	0	1,648	610
Roosevelt	9,251	129	1,192	151	0	1,343	497
Rosebud	9,028	172	646	1,095	0	1,741	644
Sanders	4,897	166	734	178	0	912	337
Sheridan	3,700	140	581	0	0	581	215
Silver Bow	35,715	345	26	13,804	0	13,830	5,117
Stillwater	2,075	231	539	0	0	539	199
Sweet Grass	1,745	183	358	0	0	358	132
Teton	3,645	301	1,156	79	0	1,235	457
Toole	5,905	184	969	238	16	1,223	452
Treasure	435	356	0	174	0	174	64
Valley	7,980	220	1,312	663	0	1,975	731
Wheatland	1,512	87	147	0	0	147	54
Wibaux	780	82	72	0	0	72	27
Yellowstone	97,582	212	953	21,085	1,203	23,241	8,599
TOTAL	558,224		61,156	93,304	2,668	157,128	58,130

[1]From either ground or surface water.
[2]To calculate water consumed by source, multiply the appropriate estimate of water withdrawn by 37 percent.

TABLE 4. SUMMARY OF RURAL DOMESTIC WATER USE BY COUNTY IN 1980

County	Population Served	Water Withdrawn and Consumed: Ground Water (af)	Surface Water (af)	All Sources (af)
Beaverhead	3,891	341	0	341
Big Horn	5,824	509	0	509
Blaine	3,872	308	0	308
Broadwater	1,531	132	1	133
Carbon	3,657	319	2	321
Carter	1,171	91	11	102
Cascade	504	44	1	45
Chouteau	2,422	206	6	212
Custer	797	70	0	70
Daniels	1,295	113	0	113
Dawson	2,650	231	1	232
Deer Lodge	2,842	248	1	249
Fallon	1,229	108	0	108
Fergus	4,617	402	2	404
Flathead	14,160	114	100	214
Gallatin	12,291	1,074	2	1,076
Garfield	1,156	101	0	101
Glacier	3,431	293	8	301
Golden Valley	641	56	0	56
Granite	1,600	135	5	140
Hill	1,287	110	3	113
Jefferson	3,482	302	2	304
Judith Basin	1,934	168	1	169
Lake	9,016	686	81	767
Lewis & Clark	11,623	1,008	9	1,017
Liberty	1,024	86	3	89
Lincoln	7,966	666	30	696
McCone	1,712	149	0	149
Madison	3,223	270	11	281
Meagher	489	43	0	43
Mineral	1,750	140	13	153
Missoula	17,238	1,503	4	1,507
Musselshell	1,743	152	1	153
Park	2,532	220	2	222
Petroleum	405	36	0	36
Phillips	2,432	213	0	213
Pondera	3,480	304	0	304
Powder River	1,440	126	0	126
Powell	2,805	246	0	246
Prairie	1,836	156	4	160
Ravalli	15,115	1,317	6	1,323
Richland	4,064	356	0	356
Roosevelt	1,216	103	2	105
Rosebud	871	76	0	76
Sanders	3,777	303	27	330
Sheridan	1,714	149	0	149
Silver Bow	2,377	208	0	208
Stillwater	3,523	298	6	304
Sweet Grass	1,471	129	0	129
Teton	2,845	246	3	249
Toole[1]	0	0	0	0
Treasure	546	47	0	47
Valley	2,270	154	45	199
Wheatland	847	74	0	74
Wibaux	696	61	0	61
Yellowstone	10,453	913	1	914
TOTAL	198,783	15,913	394	16,307

[1]Estimated as zero, unable to calculate actual use by the methods used in this report.

TABLE 5. SUMMARY OF SELF-SUPPLIED INDUSTRIAL WATER USE BY COUNTY IN 1980

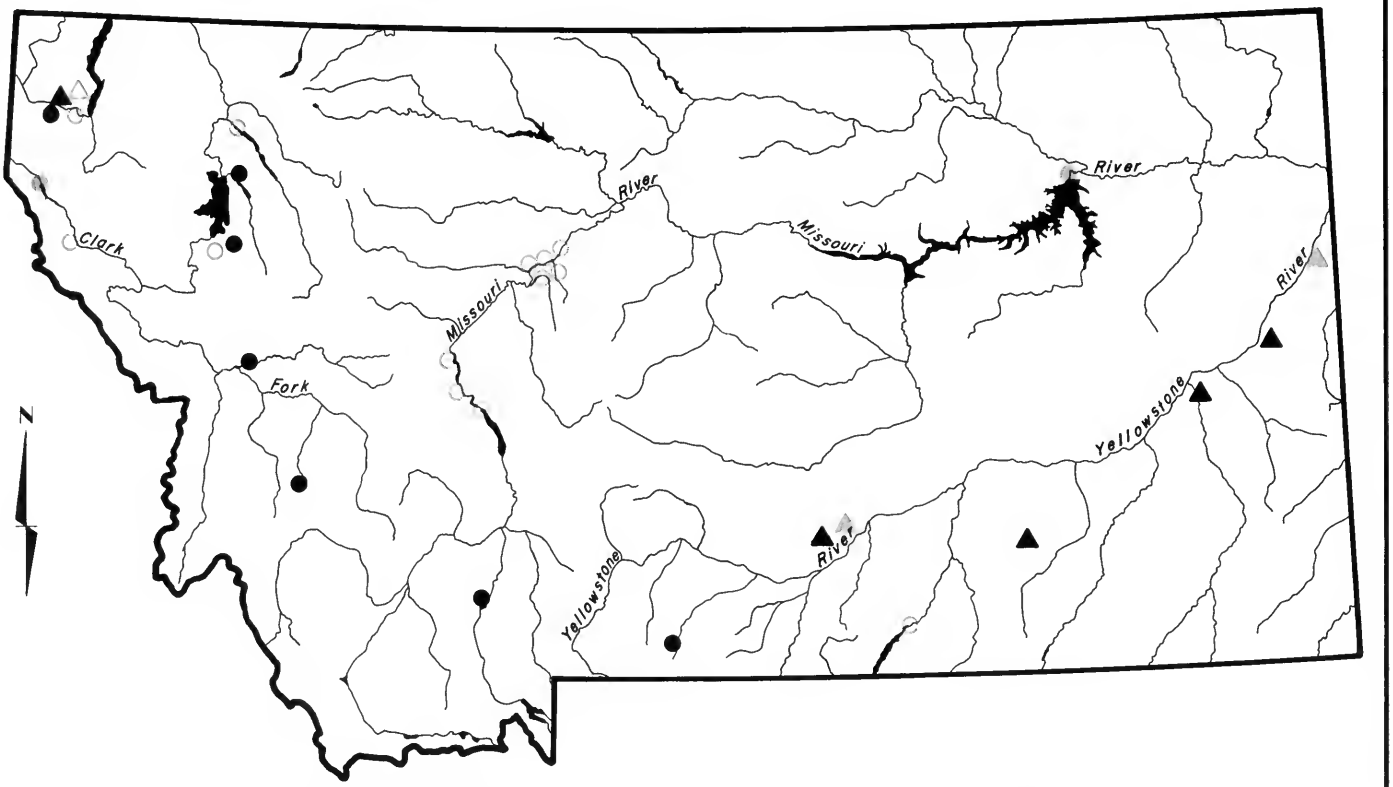
County	No. of Manufacturers Served	Water Withdrawn: Ground Water (af)	Water Withdrawn: Surface Water (af)	Water Withdrawn: All Sources (af)	Water Consumed: All Sources (af)[1]
Beaverhead	7	102	162	264	40
Big Horn	5	9	0	9	1
Blaine	2	0	0	0	0
Broadwater	3	7	0	7	1
Carbon	7	98	0	98	15
Carter	2	0	0	0	0
Cascade	38	6	482	488	73
Chouteau	5	1	0	1	0
Custer	7	8	0	8	1
Daniels	0	0	0	0	0
Dawson	9	58	0	58	9
Deer Lodge	3	2	0	2	0
Fallon	1	8	0	8	1
Fergus	11	85	0	85	13
Flathead	48	5,239	70	5,309	796
Gallatin	53	78	0	78	12
Garfield	2	0	0	0	0
Glacier	3	285	0	285	43
Golden Valley	0	0	0	0	0
Granite	2	6	0	6	1
Hill	9	11	0	11	2
Jefferson	6	258	0	258	39
Judith Basin	1	2	0	2	0
Lake	15	39	0	39	6
Lewis & Clark	26	131	729	860	129
Liberty	1	2	0	2	0
Lincoln	7	113	14,488	14,601	2,190
McCone	0	0	0	0	0
Madison	2	0	0	0	0
Meagher	1	96	0	96	14
Mineral	5	2,601	485	3,086	463
Missoula	51	19,850	2,931	22,781	3,417
Musselshell	3	1	0	1	0
Park	10	38	0	38	6
Petroleum	0	0	0	0	0
Phillips	6	2	0	2	0
Pondera	4	2	0	2	0
Powder River	1	0	0	0	0
Powell	3	2	0	2	0
Prairie	1	0	0	0	0
Ravalli	27	99	0	99	15
Richland	5	8	843	851	128
Roosevelt	7	40	0	40	6
Rosebud	5	104	0	104	16
Sanders	13	200	1	201	30
Sheridan	1	1	0	1	0
Silver Bow	22	2,431	0	2,431	365
Stillwater	3	0	0	0	0
Sweet Grass	1	0	0	0	0
Teton	6	2	0	2	0
Toole	5	0	200	200	30
Treasure	0	0	0	0	0
Valley	5	72	0	72	11
Wheatland	1	0	0	0	0
Wibaux	1	0	0	0	0
Yellowstone	75	447	9,510	9,957	1,494
TOTAL	537	32,544	29,901	62,445	9,367

[1]To calculate water consumed by source, multiply the appropriate estimate of water withdrawn by 15 percent.

TABLE 6. SUMMARY OF LIVESTOCK WATER USE
BY COUNTY IN 1980

County	Water Withdrawn and Consumed		
	Ground Water (af)	Surface Water (af)	All Sources (af)
Beaverhead	715	896	1,611
Big Horn	722	185	907
Blaine	157	698	855
Broadwater	78	208	286
Carbon	16	530	546
Carter	38	895	933
Cascade	138	531	669
Chouteau	152	454	606
Custer	128	555	683
Daniels	279	4	283
Dawson	121	319	440
Deer Lodge	20	52	72
Fallon	7	516	523
Fergus	171	1,153	1,324
Flathead	158	75	233
Gallatin	257	348	605
Garfield	193	580	773
Glacier	0	360	360
Golden Valley	280	6	286
Granite	158	126	284
Hill	58	284	342
Jefferson	49	204	253
Judith Basin	234	387	621
Lake	116	545	661
Lewis & Clark	103	304	407
Liberty	13	129	142
Lincoln	25	37	62
Madison	603	327	930
McCone	82	407	489
Meagher	201	333	534
Mineral	0	9	9
Missoula	6	75	81
Musselshell	359	1	360
Park	86	431	517
Petroleum	20	278	298
Phillips	8	869	877
Pondera	68	299	367
Powder River	697	57	754
Powell	17	470	487
Prairie	119	266	385
Ravalli	118	364	482
Richland	86	385	471
Roosevelt	65	269	334
Rosebud	205	466	671
Sanders	149	74	223
Sheridan	72	215	287
Silver Bow	18	24	42
Stillwater	351	186	537
Sweet Grass	350	185	535
Teton	43	528	571
Toole	148	88	236
Treasure	5	212	217
Valley	267	480	747
Wheatland	151	288	439
Wibaux	82	154	236
Yellowstone	29	593	622
TOTAL	8,791	18,714	27,505

FIGURE 2 – 1980 WATER USE: POWER GENERATION



THERMOELECTRIC FACILITIES

MGD	1,000 af
25.1 – 50.0	28.1 – 56.1
10.1 – 25.0	11.3 – 28.0
.0 – 10.0	.0 – 11.2

HYDROELECTRIC FACILITIES

MGD	1,000 af
6,501 – 12,000	7,294 – 13,464
1,001 – 6,500	1,123 – 7,293
0 – 1,000	0 – 1,122

TABLE 7. SUMMARY OF THERMOELECTRIC POWER GENERATION WATER USE BY COUNTY IN 1980

County[1]	Thermoelectric Water Withdrawn (af)	Thermoelectric Water Consumed (af)	Thermoelectric Power Generated (MWh)
Dawson	18	0	43
Lincoln	12,836	0	25,000
Richland	34,331	0	330,000
Rosebud	7,091	7,091	4,289,000
Yellowstone	52,622	2,210	1,287,000
TOTAL	106,898	9,301	5,931,043

[1]Only counties with thermoelectric facilities are listed.

IN-STREAM USE

HYDROELECTRIC POWER GENERATION

Production of hydroelectricity is a nonconsumptive use of water. Figure 2 shows the location of Montana's hydroelectric dams, and the amount of water that passes through their turbines. Facilities in Sanders County used the most water--19,197,000 af--for power generation followed by the Cascade County facilities which used approximately 19,183,000 af. In all 73,984,000 af of water were used to generate 10 million MWh of electricity.

Water use for the generation of hydroelectricity is summarized in table 8. Water used in one hydroelectric facility can be used again downstream. Because of this reuse, some of these county estimates may be greater than the total amount of water available for consumptive use in a basin.

TABLE 8. SUMMARY OF HYDROELECTRIC POWER GENERATION WATER USE BY COUNTY IN 1980

County[1]	Hydroelectric Water Passed Through Turbines (af)	Hydroelectric Power Generated (MWh)
Big Horn	2,316,930	875,000
Cascade	19,182,834	1,506,000
Flathead	1,677,390	637,000
Granite	14,586	4,000
Lake	5,889,378	914,000
Lewis & Clark	9,561,684	851,000
Lincoln	6,728,634	1,895,000
Madison	949,212	70,000
McCone	7,570,134	1,258,000
Missoula	832,524	17,000
Sanders	19,197,420	1,995,000
Stillwater	62,832	54,000
TOTAL	73,983,588	10,076,000

[1]Only counties with hydroelectric facilities are listed.

RESERVOIR EVAPORATION

Reservoir evaporation accounts for the loss of large amounts of water in the state. Though not a water use, reservoir evaporation was included in this report, because this water loss occurs as the indirect result of human activity. Evaporation from Flathead Lake, a natural body of water, was included because Kerr Dam has increased its surface area. Table 9 shows that the evaporation of water from reservoirs was approximately 3,925,000 af, with most evaporation occurring in the medium-sized reservoirs.

TABLE 9. RESERVOIR EVAPORATION IN 1980

Class	Number	Total Surface Area (1,000 acres)	Average Annual Evaporation (1,000 af)
Large Reservoirs[1]	8	516	1,684
Medium Reservoirs[2]	3,510	642	2,165
Small Reservoirs[3]	6,000	22	76
TOTAL	9,518	1,180	3,925

[1]Includes the state's eight largest reservoirs--Fort Peck Reservoir, Canyon Ferry Reservoir, Flathead Lake, Hungry Horse Reservoir, Bighorn Lake, Lake Elwell, Lake Koocanusa, and Noxon Rapids Reservoir.

[2]Includes all reservoirs not listed above with dam heights of at least 25 feet and storage capacities of 15 af or more, and all reservoirs with dam heights of at least six feet and storage capacities of 50 af or more.

[3]Includes all reservoirs not meeting the criteria listed above.

SUMMARY

STATEWIDE WATER USE

Figure 3 summarizes the water use data in this report. Figure 3 also illustrates the (1) water withdrawn from both ground-water and surface-water sources, (2) water returned for further use, and (3) water consumed by all use categories. Reservoir evaporation is not shown in figure 3 because it is not considered a purposeful water use, though it does result in a significant water loss.

Figure 4 displays water withdrawals for off-stream use in 1980. Irrigation required 15,044,000 af, or 97.6 percent of total withdrawals. Figure 5 shows the amount of water consumed by users and lost to evaporation. Reservoir evaporation accounted for 3,925,000 af, or 53.8 percent of the total water consumed.

WATER USE IN MAJOR RIVER BASINS

Table 10 and figure 6 summarize water use in Montana by the four major river basins: the Kootenai, the Clark Fork of the Columbia, the Missouri, and the Yellowstone. The greatest water use was in the Missouri River Basin, where 51 percent of the withdrawals and 54 percent of the total water consumption in the state occurred. More water was used in the Missouri River Basin for agriculture, municipal supply, rural domestic, livestock, and hydroelectric power than in any other basin. Water use for self-supplied industry was greatest in the Clark Fork Basin, while thermoelectric power generation water demands were highest in the Yellowstone Basin.

FIGURE 3 – SUMMARY OF 1980 WATER USE

(1,000 acre-feet)

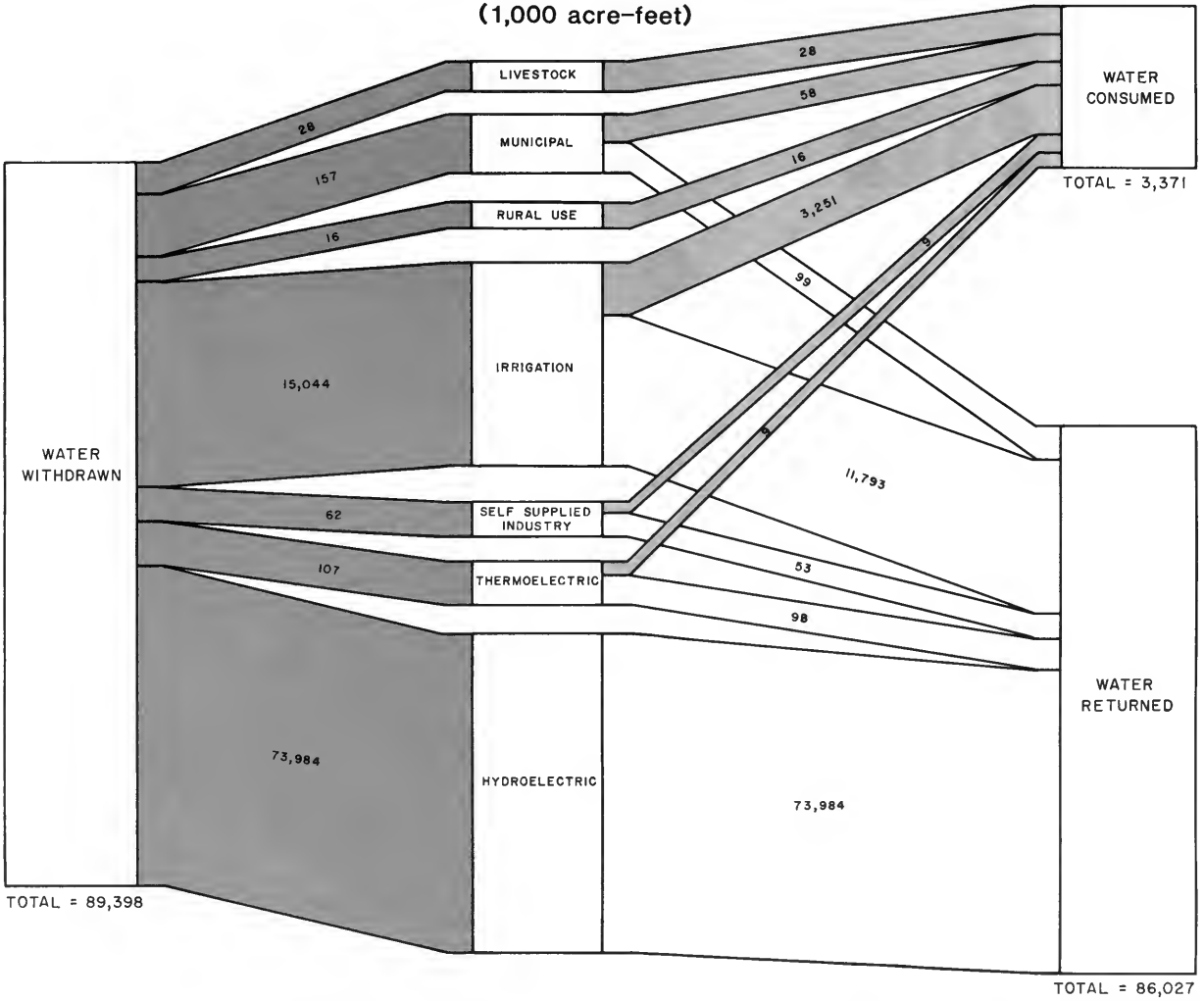


FIGURE 4 – 1980 WATER WITHDRAWALS

	1,000 af	PERCENT
- IRRIGATION	15,044	97.6
- MUNICIPAL	157	1.0
- THERMOELECTRIC POWER GENERATION	107	.7
- SELF-SUPPLIED INDUSTRY	62	.4
- LIVESTOCK	28	.2
- RURAL DOMESTIC	16	.1
	15,414	100.0

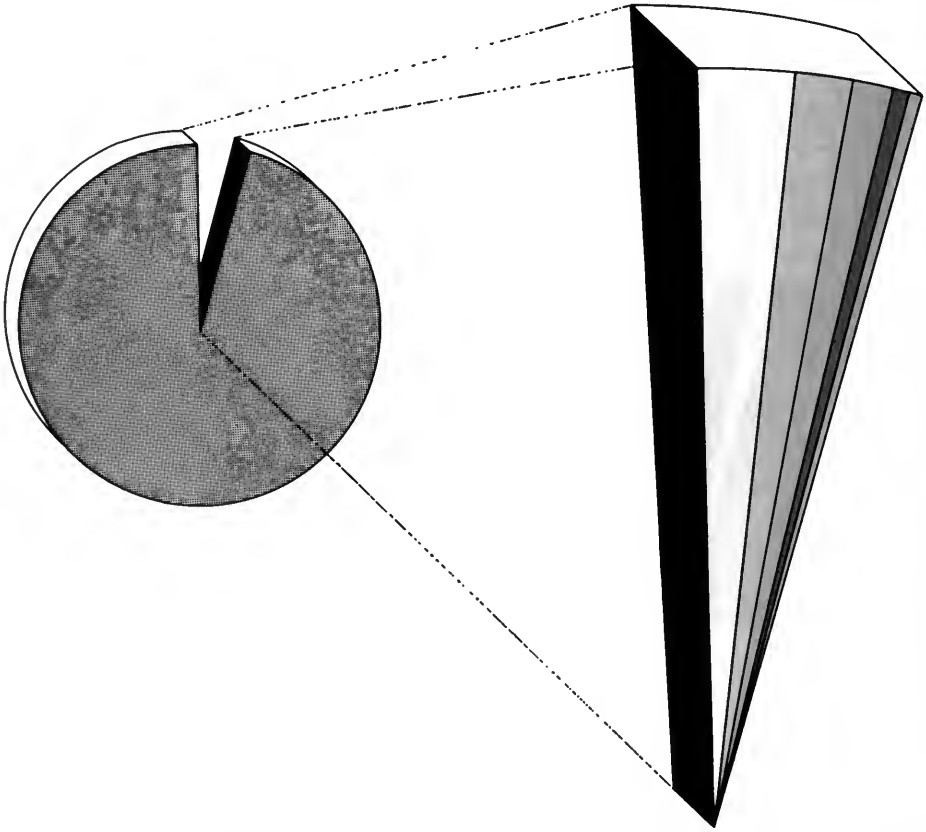


FIGURE 5 – 1980 WATER CONSUMPTION

	1,000 af	PERCENT
- RESERVOIR EVAPORATION	3,925	53.8
- IRRIGATION	3,251	44.6
- MUNICIPAL	58	.8
- LIVESTOCK	28	.4
- RURAL DOMESTIC	16	.2
- THERMOELECTRIC POWER GENERATION	9	.1
- SELF-SUPPLIED INDUSTRY	9	.1
	7,296	100.0

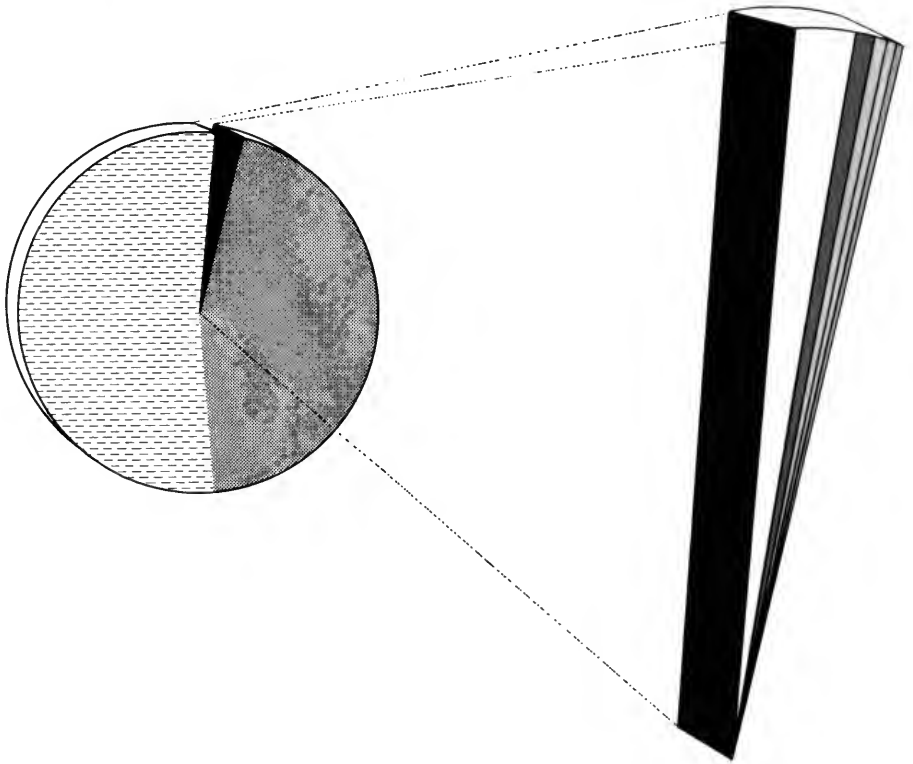


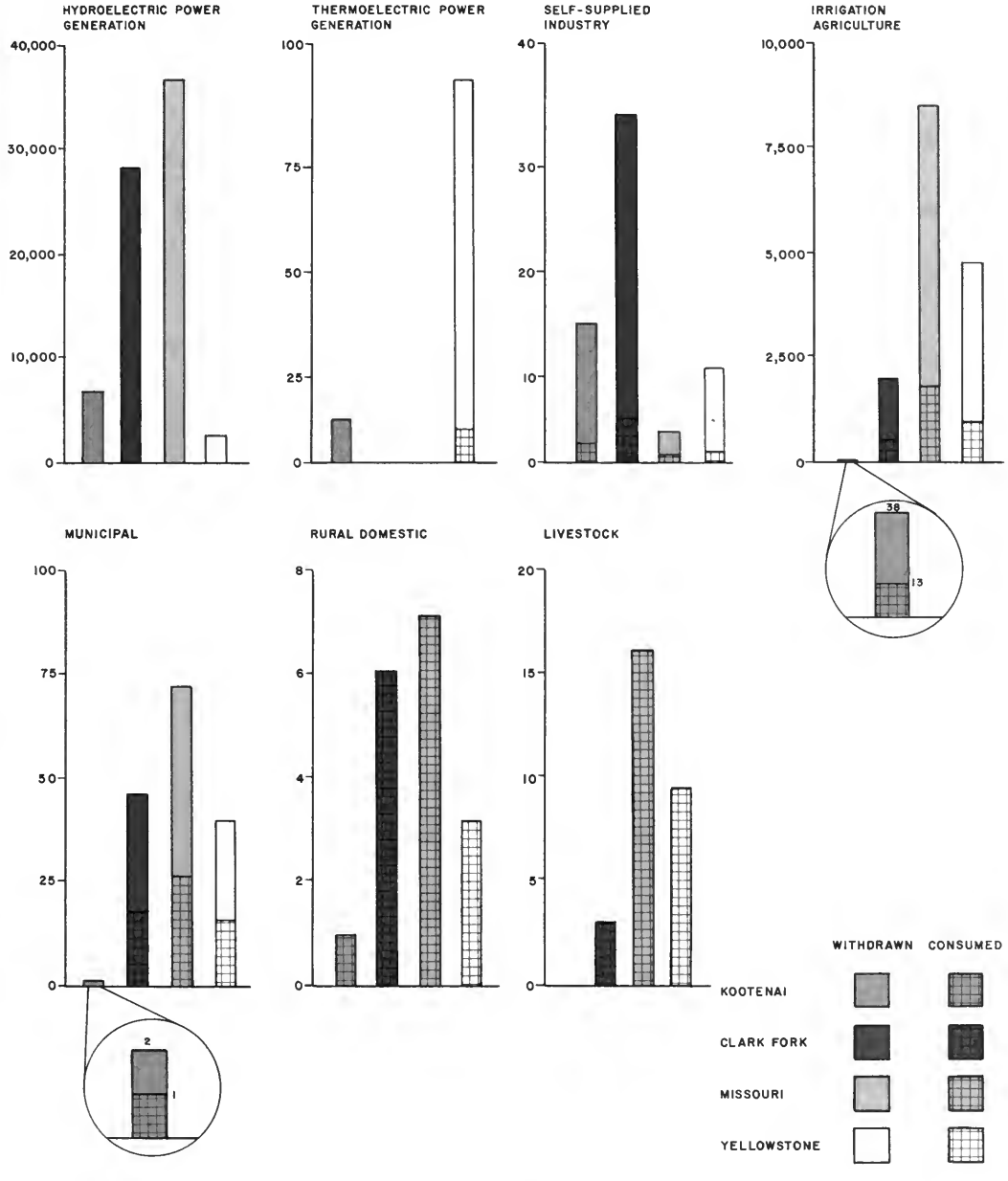
TABLE 10. WATER USE BY MAJOR RIVER BASINS IN 1980
(THOUSAND ACRE-FEET PER YEAR)

	Hydroelectric Power Generation	Thermoelectric Power Generation	Self-Supplied Industry	Municipal	Rural Domestic	Irrigation	Live-stock	Basin Total
Kootenai								
Withdrawn	6,729	13	15	2	1	38	*	6,798
Consumed	0	0	2	1	1	13	*	17
Clark Fork								
Withdrawn	27,611	0	33	46	5	1,852	3	29,550
Consumed	0	0	5	17	5	521	3	551
Missouri[1]								
Withdrawn	37,264	0	3	71	7	7,902	16	45,263
Consumed	0	0	1	25	7	1,744	16	1,793
Yellowstone[2]								
Withdrawn	2,380	94	11	38	3	4,468	9	7,003
Consumed	0	9	1	15	3	943	9	980
State Total[3]								
Withdrawn	73,984	107	62	157	16	14,260	28	88,614
Consumed	0	9	9	58	16	3,221	28	3,341

[1]Includes St. Mary drainage.
[2]Includes Little Missouri drainage.
[3]These figures are based on hydrologic unit totals for each use as shown in Appendix A and, due to rounding, vary slightly from the totals listed in county tables.
*Insignificant.

FIGURE 6 - 1980 WATER USE IN THE MAJOR RIVER BASINS

(1,000 acre-feet)



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APPENDIX A

HYDROLOGIC UNIT TABLES

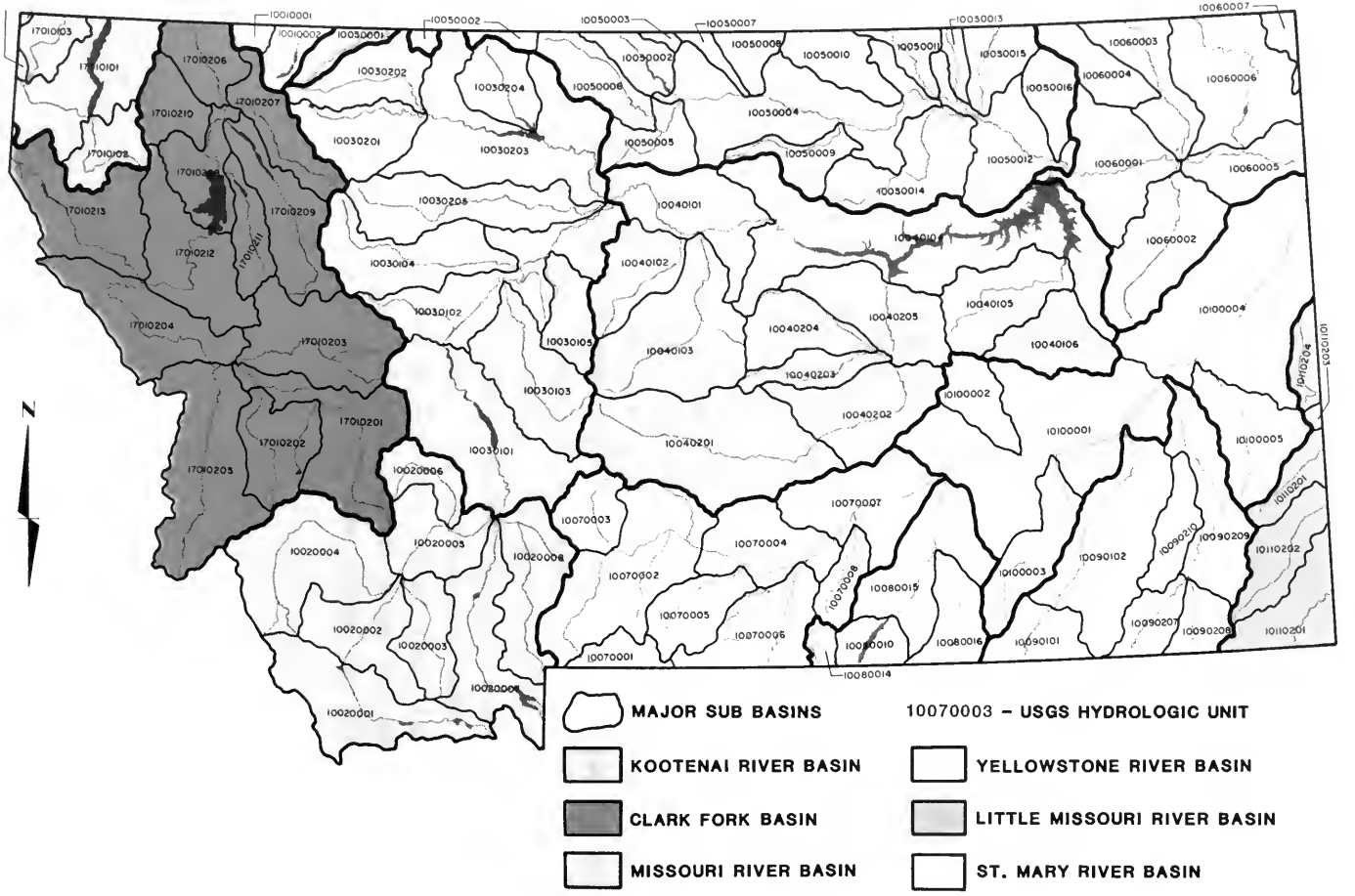
APPENDIX A

The following tables present detailed water use information by USGS hydrologic unit (USGS 1982) for each of the water uses discussed in this report: irrigation, municipal, rural domestic, self-supplied industrial, livestock, and power generation. The tables present information on water withdrawals and water consumption, and show whether the withdrawn water came from a surface- or ground-water source. The data are expressed in acre-feet (af).

In the USGS basin classification system, hydrologic units are catalogued by 8-digit numbers. The first four digits represent a major subbasin, while the second four denote a specific river or creek. The major subbasins were grouped into four major river basins for Montana: the Missouri, Yellowstone, Kootenai, and Clark Fork. The Missouri River Basin in Montana consists of hydrologic units beginning with the numbers 1002, 1003, 1004, 1005, and 1006, while the Yellowstone River Basin includes hydrologic units beginning with the numbers 1007, 1008, 1009, and 1010. In the USGS system, the Kootenai and Clark Fork are subbasins of the Columbia River (1701), but this report defines them as two separate major river basins. Hydrologic unit numbers beginning with the six digits, 170101, are subbasins of the Kootenai River Basin, while numbers beginning with 170102 are assigned to subbasins of the Clark Fork Basin.

There are also two minor drainage basins in Montana: the Hudson Bay Basin, which is indicated by hydrologic unit numbers beginning with 1001, and the Little Missouri River Basin, indicated by hydrologic units beginning with 1011. Figure A-1 shows these hydrologic units. The basin names that correspond with the numbers shown are listed in the key, which follows the figure.

FIGURE A-1 – USGS HYDROLOGIC UNITS



Key to Figure A-1

HYDROLOGIC UNIT			SUBBASIN
Hudson Bay Drainage Basin:	1001	0001	Belly
		0002	St. Mary
Missouri River Basin:	1002	0001	Red Rock
		0002	Beaverhead
		0003	Ruby
		0004	Big Hole
		0005	Jefferson
		0006	Boulder
		0007	Madison
		0008	Gallatin
	1003	0101	Upper Missouri
		0102	Upper Missouri-Dearborn
		0103	Smith
		0104	Sun
		0105	Belt
	1003	0201	Two Medicine
		0202	Cut Bank
		0203	Marias
		0204	Willow
		0205	Teton
	1004	0101	Bullwhacker-Dog
		0102	Arrow
		0103	Judith
		0104	Fort Peck Reservoir
		0105	Big Dry
		0106	Little Dry
	1004	0201	Upper Musselshell
		0202	Middle Musselshell
		0203	Flatwillow
		0204	Box Elder
		0205	Lower Musselshell
	1005	0001	Milk Headwaters
		0002	Upper Milk
		0003	Wild Horse Lake
		0004	Middle Milk
		0005	Big Sandy
		0006	Sage
		0007	Lodge
		0008	Battle
		0009	Peoples
		0010	Cottonwood
		0011	Whitewater

HYDROLOGIC UNIT			SUBBASIN
Missouri River Basin: (cont'd.)	1005	0012	Lower Milk
		0013	Frenchman
		0014	Beaver
		0015	Rock
		0016	Porcupine
	1006	0001	Prairie Elk-Wolf
		0002	Redwater
		0003	Poplar
		0004	West Fork Poplar
		0005	Charlie-Little Muddy
		0006	Big Muddy
		0007	Brush Lake Closed Basin
Yellowstone River Basin:	1007	0001	Yellowstone Headwaters
		0002	Upper Yellowstone
		0003	Shields
		0004	Upper Yellowstone-Lake Basin
		0005	Stillwater
		0006	Clarks Fork Yellowstone
		0007	Upper Yellowstone-Pompeys Pillar
		0008	Pryor
	1008	0010	Big Horn Lake
		0014	Shoshone
		0015	Lower Bighorn
		0016	Little Bighorn
	1009	0207	Middle Powder
		0208	Little Powder
		0209	Lower Powder
		0210	Mizpah
	1010	0001	Lower Yellowstone-Sunday
		0002	Big Porcupine
		0003	Rosebud
		0004	Lower Yellowstone
		0005	O'Fallon
Little Missouri River Basin:	1011	0201	Upper Little Missouri
		0202	Box Elder
		0203	Middle Little Missouri
		0204	Beaver
Kootenai River Basin:	1701	0101	Upper Kootenai
		0102	Fisher
		0103	Yaak
		0104	Lower Kootenai
		0105	Moyie

HYDROLOGIC UNIT		SUBBASIN	
Clark Fork Basin:	1701	0201	Upper Clark Fork
		0202	Flint-Rock
		0203	Blackfoot
		0204	Middle Clark Fork
		0205	Bitterroot
		0206	North Fork Flathead
		0207	Middle Fork Flathead
		0208	Flathead Lake
		0209	South Fork Flathead
		0210	Stillwater
		0211	Swan
		0212	Lower Flathead
		0213	Lower Clark Fork

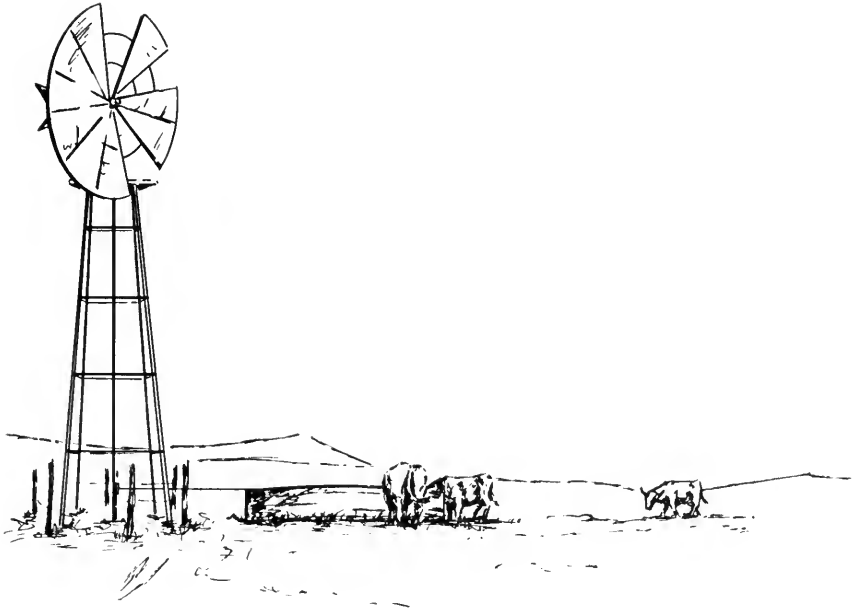


TABLE A-1. IRRIGATION: 1980 WATER USE IN MONTANA BY HYDROLOGIC UNIT

Hydrologic Unit	Lands Irrigated By: Ground Water (acres)	Lands Irrigated By: Surface Water (acres)[1]	Water Withdrawn: Ground Water (af)	Water Withdrawn: Surface Water (af)	Water Withdrawn: All Sources (af)[2]	Water Consumed: Ground Water (af)	Water Consumed: Surface Water (af)	Water Consumed: All Sources (af)[2]
10010001	0	0	0	0	0	0	0	0
10010002	43	488 (229)	39	1,952 (172)	2,163	29	332 (69)	430
10020001	288	71,714	335	324,600	324,935	248	61,674	61,922
10020002	432	107,481	549	531,748	532,297	406	101,032	101,438
10020003	107	35,495	136	185,363	185,499	100	33,365	33,465
10020004	566	140,943	673	620,149	620,822	498	124,030	124,528
10020005	628	56,511	1,078	398,716	399,794	797	71,797	72,594
10020006	331	23,289	501	124,208	124,709	371	26,084	26,455
10020007	873	47,626	1,156	259,297	260,453	855	46,673	47,528
10020008	5,652	112,093	8,478	592,491	600,969	6,274	124,423	130,697
10030101	4,656	92,341	7,424	518,868	526,292	5,494	108,962	114,456
10030102	471	14,572 (4,602)	866	86,165 (10,779)	97,810	640	19,818 (2,803)	23,261
10030103	1,068	35,412 (6,249)	1,688	243,718 (17,497)	262,903	1,249	41,432 (4,374)	47,055
10030104	5,126	108,264 (14,763)	7,966	565,925 (22,318)	596,209	5,895	124,504 (7,588)	137,987
10030105	9	687 (121)	15	3,435 (339)	3,789	11	859 (85)	955
10030201	1,879	29,765 (15,333)	2,336	130,399 (15,640)	148,375	1,729	27,384 (6,256)	35,369
10030202	1,370	15,419 (7,256)	1,481	72,560 (5,442)	79,483	1,096	12,335 (2,177)	15,608
10030203	2,267	47,945 (44,257)	3,921	266,824 (57,301)	328,046	2,902	61,370 (21,774)	86,046
10030204	6	2,047 (3,640)	11	11,429 (4,532)	15,972	8	2,743 (1,813)	4,564
10030205	1,057	53,457 (15,968)	1,871	333,470 (16,567)	351,908	1,385	70,029 (6,627)	78,041
10040101	182	2,337 (1,432)	359	15,509 (1,658)	17,526	266	3,412 (746)	4,424
10040102	411	6,515 (3,356)	789	46,256 (3,831)	50,876	584	9,251 (1,839)	11,674
10040103	1,110	18,838 (4,710)	1,980	138,145 (4,710)	144,835	1,465	24,866 (2,736)	29,067
10040104	782	9,279 (8,565)	1,670	52,360 (9,746)	63,776	1,235	14,661 (5,653)	21,549
10040105	319	592 (4,787)	724	2,617 (7,238)	10,579	536	944 (3,619)	5,099
10040106	182	656 (2,466)	401	3,055 (3,595)	7,051	297	1,069 (1,798)	3,164
10040201	1,403	55,443 (4,173)	2,503	457,405 (3,547)	463,455	1,852	73,185 (1,419)	76,456
10040202	238	14,443 (2,351)	527	118,433 (2,400)	121,360	390	23,686 (1,032)	25,108
10040203	172	4,100 (1,295)	362	29,073 (1,351)	30,786	268	6,396 (783)	7,447
10040204	649	13,013 (3,887)	1,324	93,570 (3,954)	98,848	980	19,650 (2,293)	22,923
10040205	263	2,763 (3,243)	579	16,085 (3,780)	20,444	429	4,504 (2,192)	7,125
10050001	91	1,026 (483)	85	4,164 (362)	4,611	63	708 (145)	916
10050002	304	1,330 (1,440)	563	7,592 (1,742)	9,897	416	1,822 (697)	2,935
10050003	250	674 (598)	503	4,184 (747)	5,434	372	1,004 (299)	1,675
10050004	7,573	69,245 (26,929)	14,634	430,523 (31,311)	476,468	10,829	99,020 (15,969)	125,818
10050005	480	2,623 (2,235)	934	16,422 (2,822)	20,178	691	3,777 (1,129)	5,597
10050006	347	1,490 (1,322)	647	8,940 (1,642)	11,229	479	2,056 (657)	3,192
10050007	452	1,550 (1,375)	892	9,429 (1,719)	12,040	660	2,263 (687)	3,610
10050008	508	4,223 (3,744)	954	24,458 (4,680)	30,092	706	5,870 (1,872)	8,448
10050009	547	7,950 (1,628)	1,035	46,375 (1,824)	49,234	766	11,130 (1,058)	12,954

[1]Figures in parentheses refer to partial service irrigation.
[2]Includes partial service irrigation.

Table A-1 (cont'd.)

Hydrologic Unit	Lands Irrigated By Ground Water (acres)	Lands Irrigated By Surface Water (acres)[1]	Water Withdrawn Ground Water (af)	Water Withdrawn Surface Water (af)	Water Withdrawn All Sources (af)[2]	Water Consumed Ground Water (af)	Water Consumed Surface Water (af)	Water Consumed All Sources (af)[2]
10050010	371	5,727 (1,173)	707	35,109 (1,314)	37,130	523	8,075 (762)	9,360
10050011	160	3,357 (687)	309	22,859 (770)	23,938	229	4,800 (446)	5,475
10050012	2,179	28,282 (15,908)	4,211	175,840 (17,608)	197,659	3,116	40,443 (10,213)	53,772
10050013	125	2,606 (572)	241	17,745 (641)	18,627	179	3,726 (372)	4,277
10050014	1,534	29,078 (7,729)	2,985	199,392 (8,635)	211,012	2,209	41,872 (5,008)	49,089
10050015	282	3,468 (2,125)	545	20,663 (2,352)	23,560	403	4,959 (1,364)	6,726
10050016	130	1,593 (977)	251	9,492 (1,080)	10,823	186	2,278 (626)	3,090
10060001	1,004	17,687 (19,944)	2,008	87,256 (21,938)	111,202	1,486	26,177 (12,724)	40,387
10060002	34	3,170 (2,490)	68	14,313 (2,664)	17,045	51	4,723 (1,598)	6,372
10060003	1,344	2,208 (1,353)	2,761	13,425 (1,516)	17,702	2,043	3,356 (879)	6,278
10060004	536	998 (537)	1,086	5,988 (602)	7,676	804	1,497 (349)	2,650
10060005	307	9,640 (3,387)	647	79,149 (3,647)	83,443	479	15,038 (2,188)	17,705
10060006	6,860	1,456 (5,162)	13,905	8,736 (5,678)	28,319	10,290	2,184 (3,293)	15,767
10060007	951	(327)	1,928	(357)	2,285	1,426	(207)	1,633
10070001	573	20,256 (413)	643	105,078 (326)	106,047	475	16,812 (130)	17,417
10070002	1,113	71,627 (1,462)	2,000	595,399 (1,155)	598,554	1,480	95,264 (462)	97,206
10070003	1,201	35,203	1,915	244,350	246,265	1,417	41,539	42,956
10070004	1,288	83,720 (846)	2,263	572,821 (812)	575,896	1,674	108,836 (325)	110,835
10070005	292	25,986 (262)	469	171,796 (262)	172,527	347	30,923 (105)	31,375
10070006	1,051	147,650 (1,491)	1,761	1,444,287 (1,327)	1,447,375	1,303	183,086 (531)	184,920
10070007	846	26,190 (264)	1,509	157,140 (240)	158,889	1,117	34,571 (96)	35,784
10070008	131	3,570 (36)	225	20,609 (32)	20,866	166	4,534 (13)	4,713
10080010	33	812 (16)	35	3,376 (13)	3,424	26	641 (5)	672
10080014	18	3,509	30	26,756	26,786	22	4,281	4,303
10080015	2,700	46,362 (946)	4,962	300,249 (783)	305,994	3,672	63,052 (313)	67,037
10080016	1,060	17,521 (357)	1,934	112,635 (290)	114,859	1,431	23,653 (116)	25,200
10090101	240	4,588 (510)	411	26,485 (431)	27,327	305	5,827 (172)	6,304
10090102	444	13,749 (17,498)	906	61,062 (18,276)	80,244	670	20,761 (9,869)	31,300
10090207	90	2,117 (9,022)	192	7,117 (10,024)	17,333	142	3,345 (5,413)	8,900
10090208	113	1,463 (7,145)	238	4,856 (23,620)	28,714	176	2,282 (12,991)	15,449
10090209	425	5,535 (11,761)	879	23,524 (13,035)	37,438	650	8,468 (7,821)	16,939
10090210	105	3,395 (6,035)	223	14,406 (6,403)	21,032	165	5,330 (3,778)	9,273
10100001	1,939	54,505 (15,373)	3,642	315,675 (14,792)	334,109	2,695	75,762 (6,656)	85,113
10100002	63	2,010 (670)	112	10,613 (613)	11,338	83	2,653 (251)	2,987
10100003	72	1,672 (206)	122	9,500 (167)	9,789	90	2,090 (67)	2,247

[1]Figures in parentheses refer to partial service irrigation.
[2]Includes partial service irrigation.

Table A-1 (cont'd.)

Bydrologic Unit	Lands Irrigated By Ground Water (acres)	Lands Irrigated By Surface Water (acres)[1]	Water Withdrawn Ground Water (af)	Water Withdrawn Surface Water (af)	Water Withdrawn All Sources (af)[2]	Water Consumed Ground Water (af)	Water Consumed Surface Water (af)	Water Consumed All Sources (af)[2]
10100004	1,517	55,011 (19,328)	3,136	323,718 (20,713)	347,567	2,321	84,167 (12,428)	98,916
10100005	478	1,070 (4,279)	1,001	3,949 (4,714)	9,664	741	1,658 (2,875)	5,274
10110201	1,977	1,826 (28,614)	3,981	6,183 (35,210)	45,374	2,946	2,721 (20,774)	26,441
10110202	741	811 (12,703)	1,472	2,772 (16,120)	20,364	1,089	1,192 (9,349)	11,630
10110203	0	0	0	0	0	0	0	0
10110204	12	10 (508)	26	40 (549)	615	19	16 (297)	332
17010101	252	7,639	453	31,749	32,202	335	10,160	10,495
17010102	423	2,853	446	4,838	5,284	330	2,225	2,555
17010103	2	112	2	317	319	2	95	97
17010104	1	12	2	54	56	1	16	17
17010105	0	8	0	23	23	0	7	7
17010201	531	65,891	689	287,524	288,213	510	63,255	63,765
17010202	480	33,779	598	124,486	125,084	442	31,077	31,519
17010203	1,210	27,611	1,488	104,692	106,180	1,101	25,126	26,227
17010204	1,162	20,771	2,104	81,862	83,966	1,557	27,833	29,390
17010205	1,353	111,422	2,212	481,502	483,714	1,637	134,821	136,458
17010206	702	3,429	702	4,788	5,490	519	2,537	3,056
17010207	0	0	0	0	0	0	0	0
17010208	2,304	19,433	3,580	54,507	58,087	2,650	22,348	24,998
17010209	0	0	0	0	0	0	0	0
17010210	1,839	9,373	2,560	18,566	21,126	1,894	9,654	11,548
17010211	51	877	74	3,157	3,231	55	947	1,002
17010212	7,393	129,516	13,188	610,575	623,763	9,759	170,961	180,720
17010213	650	9,056	1,159	51,973	53,132	858	11,954	12,812

[1]Figures in parentheses refer to partial service irrigation.
[2]Includes partial service irrigation.

TABLE A-2. MUNICIPAL SYSTEMS: 1980 WATER USE IN MONTANA BY HYDROLOGIC UNIT

Hydrologic Unit	Population Served	Per Capita Use (gpd)	Water Withdrawn: Ground Water (af)	Water Withdrawn: Surface Water (af)	Water Withdrawn: Purchased Water (af)	Water Withdrawn: All Sources (af)	Water Consumed: All Sources (af)[1]
10010001	0	0	0	0	0	0	0
10010002	0	0	0	0	0	0	0
10020001	200	76	17	0	0	17	6
10020002	4,593	371	642	1,271	0	1,913	708
10020003	1,024	210	66	176	0	242	90
10020004	35,579	345	0	13,804	0	13,804	5,107
10020005	2,278	202	516	0	0	516	191
10020006	1,789	765	1,538	0	0	1,538	569
10020007	1,700	150	286	0	0	286	106
10020008	28,265	250	1,653	6,269	0	7,921	2,931
10030101	33,860	253	2,992	6,626	0	9,619	3,559
10030102	79,571	189	599	14,981	1,327	16,907	6,256
10030103	1,540	182	8	307	0	315	117
10030104	2,683	253	746	17	0	763	282
10030105	1,057	29	12	21	0	34	13
10030201	150	36	0	6	0	6	2
10030202	6,546	243	975	778	371	1,790	662
10030203	9,323	189	867	1,116	0	1,984	734
10030204	644	323	234	0	0	234	87
10030205	2,749	282	811	60	0	872	323
10040101	100	356	40	0	0	40	15
10040102	558	96	60	0	0	60	22
10040103	8,491	244	2,332	0	0	2,332	863
10040104	0	0	0	0	0	0	0
10040105	500	119	67	0	0	67	25
10040106	0	0	0	0	0	0	0
10040201	2,013	144	234	91	0	325	120
10040202	700	1,366	1,031	43	0	1,074	397
10040203	0	0	0	0	0	0	0
10040204	700	145	106	8	0	114	42
10040205	0	0	0	0	0	0	0
10050001	0	0	0	0	0	0	0
10050002	3,440	110	40	369	16	425	157
10050003	0	0	0	0	0	0	0
10050004	19,883	134	1,640	1,348	6	2,993	1,107
10050005	999	224	234	17	0	251	93
10050006	90	20	2	0	0	2	1
10050007	0	0	0	0	0	0	0
10050008	0	0	0	0	0	0	0
10050009	0	0	0	0	0	0	0
10050010	75	166	14	0	0	14	5
10050011	0	0	0	0	0	0	0
10050012	6,424	188	1,046	307	0	1,353	501
10050013	0	0	0	0	0	0	0
10050014	255	182	26	26	0	52	19
10050015	0	0	0	0	0	0	0
10050016	780	203	178	0	0	178	66
10060001	4,774	175	582	356	0	938	347
10060002	1,439	103	166	0	0	166	61
10060003	4,363	147	721	0	0	721	267

[1]To calculate water consumed by source, multiply the appropriate water withdrawn estimate by 37 percent.

Table A-2 (cont'd.)

Hydrologic Unit	Popu-lation Served	Per Capita Use (gpd)	Water Withdrawn: Ground Water (af)	Water Withdrawn: Surface Water (af)	Water Withdrawn: Purchased Water (af)	Water Withdrawn: All Sources (af)	Water Consumed: All Sources (af)[1]
10060004	0	0	0	0	0	0	0
10060005	1,899	125	116	151	0	267	99
10060006	3,922	61	669	0	0	269	100
10060007	300	178	60	0	0	60	22
10070001	995	378	395	27	0	422	156
10070002	10,527	236	2734	60	0	2,795	1,034
10070003	574	169	89	20	0	109	40
10070004	92,952	218	536	21,064	1,203	22,804	8,437
10070005	707	252	200	0	0	200	74
10070006	4,400	322	663	929	0	1,592	589
10070007	6,035	115	760	20	0	780	289
10070008	0	0	0	0	0	0	0
10080010	257	184	38	14	0	53	20
10080014	0	0	0	0	0	0	0
10080015	3,640	184	28	725	0	753	279
10080016	1,022	152	175	0	0	175	65
10090101	350	183	72	0	0	72	27
10090102	556	216	134	1	0	135	50
10090207	918	133	137	0	0	137	51
10090208	160	807	145	0	0	145	54
10090209	0	0	0	0	0	0	0
10090210	0	0	0	0	0	0	0
10100001	18,717	145	231	2,809	0	3,041	1,125
10100002	0	0	0	0	0	0	0
10100003	2,496	183	513	0	0	513	190
10100004	16,877	234	2,045	1,876	0	4,432	1,640
10100005	2,531	167	475	0	0	475	176
10110201	628	132	93	0	0	93	34
10110202	0	0	0	0	0	0	0
10110203	0	0	0	0	0	0	0
10110204	780	82	72	0	0	72	27
17010101	9,780	150	882	760	561	1,647	609
17010102	0	0	0	0	0	0	0
17010103	0	0	0	0	0	0	0
17010104	0	0	0	0	0	0	0
17010105	0	0	0	0	0	0	0
17010201	13,959	388	5,947	129	0	6,076	2,248
17010202	1,099	43	0	53	0	53	20
17010203	720	481	49	340	0	389	144
17010204	51,493	406	11,738	11,756	0	23,495	8,693
17010205	14,381	450	5,868	1,398	0	7,266	2,688
17010206	0	0	0	0	0	0	0
17010207	100	53	0	0	560	6	2
17010208	21,867	171	3,454	684	67	4,205	1,556
17010209	0	0	0	0	0	0	0
17010210	19,320	139	942	2,067	0	3,009	1,113
17010211	1,025	76	4	83	0	88	33
17010212	6,404	137	812	177	0	989	366
17010213	4,005	164	586	154	0	739	273

[1]To calculate water consumed by source, multiply the appropriate water withdrawn estimate by 37 percent.

TABLE A-3. RURAL DOMESTIC: 1980 WATER USE IN MONTANA BY HYDROLOGIC UNIT

Hydrologic Unit	Population Served	Water Withdrawn and Consumed: Ground Water (af)	Surface Water (af)	All Sources (af)
10010001	266	17	6	23
10010002	534	35	12	47
10020001	1,388	121	0	121
10020002	861	75	0	75
10020003	982	86	0	86
10020004	3,075	269	0	269
10020005	2,292	201	0	201
10020006	1,736	148	3	151
10020007	4,193	358	9	367
10020008	7,292	637	1	638
10030101	7,062	617	1	618
10030102	1,847	244	5	249
10030103	444	39	0	39
10030104	4,316	370	7	377
10030105	151	12	0	12
10030201	1,385	121	0	121
10030202	1,125	99	0	99
10030203	2,870	245	7	252
10030204	38	3	0	3
10030205	2,520	148	99	247
10040101	1,463	128	0	128
10040102	611	49	3	52
10040103	1,433	70	56	126
10040104	3,019	37	227	264
10040105	390	34	0	34
10040106	350	30	0	30
10040201	1,844	162	0	162
10040202	1,423	149	0	149
10040203	474	42	0	42
10040204	794	70	0	70
10040205	807	71	0	71
10050001	522	38	8	46
10050002	439	31	7	38
10050003	45	3	1	4
10050004	2,114	158	27	185
10050005	461	35	5	40
10050006	500	44	0	44
10050007	120	8	2	10
10050008	387	28	5	33
10050009	602	53	0	53
10050010	675	50	8	58
10050011	199	18	0	18
10050012	1,228	94	14	108
10050013	102	9	0	9
10050014	973	85	0	85
10050015	532	47	0	47
10050016	506	38	6	44
10060001	1,774	100	55	155
10060002	3,549	311	0	311
10060003	1,434	126	0	126
10060004	578	50	0	50
10060005	2,076	117	65	182
10060006	2,674	232	1	233
10060007	368	31	1	32
10070001	581	49	1	50
10070002	2,979	259	1	260
10070003	1,238	107	1	108
10070004	3,982	349	0	349
10070005	1,711	148	2	150
10070006	3,229	282	1	283
10070007	6,394	560	0	560
10070008	2,040	178	0	178
10080010	996	88	0	88
10080014	418	37	0	37
10080015	2,780	243	0	243
10080016	1,258	110	0	110
10090101	861	75	0	75
10090102	1,862	163	0	163
10090207	347	30	0	30
10090208	310	27	0	27
10090209	556	48	0	48
10090210	235	20	0	20
10100001	1,791	157	0	157
10100002	163	15	0	15
10100003	728	64	0	64
10100004	4,480	392	1	393
10100005	931	82	0	82
10110201	860	75	0	75
10110202	447	39	0	39
10110203	49	4	0	4
10110204	449	39	0	39
17010101	4,524	385	11	396
17010102	1,930	151	18	169
17010103	1,243	76	32	108
17010104	132	8	4	12
17010105	88	6	2	8
17010201	4,723	411	2	413
17010202	1,988	170	3	173
17010203	8,372	687	45	732
17010204	4,696	390	20	410
17010205	18,052	1,573	6	1,579
17010206	2,985	242	19	261
17010207	2,898	242	11	253
17010208	3,802	309	25	334
17010209	4,272	374	0	374
17010210	1,906	155	12	167
17010211	3,873	310	29	339
17010212	6,693	549	37	586
17010213	4,237	335	36	371

TABLE A-4. SELF-SUPPLIED INDUSTRY: 1980 WATER USE IN MONTANA BY HYDROLOGIC UNIT

Hydrologic Unit[1]	Water Withdrawn: Ground Water (af)	Water Withdrawn: Surface Water (af)	Water Withdrawn: All Sources (af)	Water Consumed: All Sources (af)[2]
10020002	102	162	264	40
10020005	18	0	18	3
10020007	2	0	2	0
10020008	375	0	375	56
10030101	758	729	1,487	223
10030102	1	482	483	72
10030103	96	0	96	14
10030105	6	0	6	1
10030202	285	0	285	43
10030203	6	200	206	31
10030205	1	0	1	0
10040104	88	0	88	13
10040202	1	0	1	0
10050004	13	0	13	2
10050012	72	0	72	11
10060001	40	0	40	6
10060006	1	0	1	0
10070002	38	0	38	6
10070004	447	9,510	9,957	1,494
10080014	96	0	96	14
10080015	9	0	9	1
10090102	108	0	108	16
10100002	6	0	6	1
10100004	66	843	909	136
10100005	8	0	8	1
17010101	113	14,488	14,601	2,190
17010201	2,440	0	2,440	366
17010203	361	2,931	3,292	494
17010204	22,112	485	22,597	3,390
17010205	100	0	100	15
17010208	5,252	0	5,252	788
17010210	18	70	88	13
17010211	9	0	9	1
17010212	1	0	1	0
17010213	200	1	201	30

[1]For hydrologic units not listed, water use equals zero.
[2]To calculate water consumed by source, multiply the appropriate estimate of water withdrawn by 15 percent.

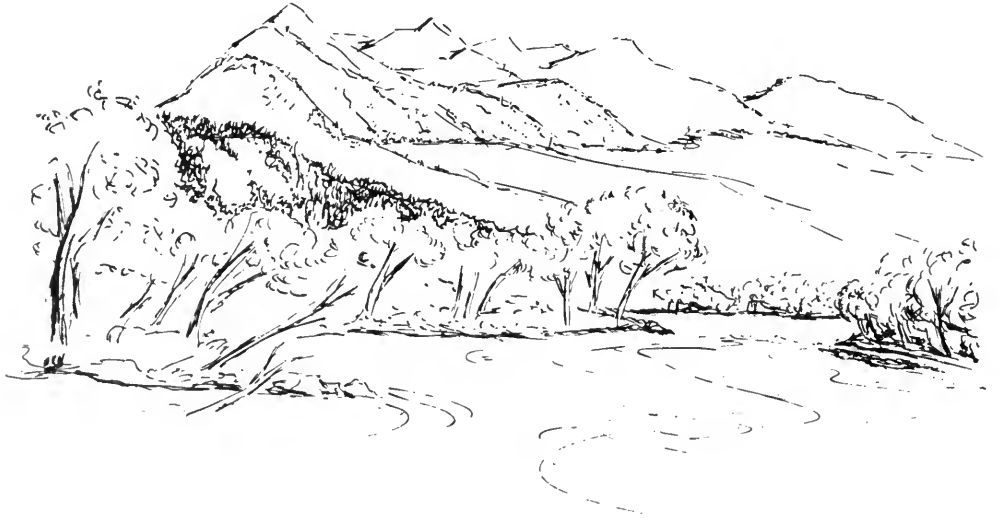
TABLE A-5. LIVESTOCK: 1980 WATER USE IN MONTANA BY HYDROLOGIC UNIT

Hydrologic Unit	Water Withdrawn and Consumed: Ground Water (af)	Surface Water (af)	All Sources (af)
10010001	0	24	24
10010002	0	47	47
10020001	372	353	725
10020002	301	89	390
10020003	50	242	292
10020004	177	456	633
10020005	31	232	263
10020006	27	99	126
10020007	69	459	528
10020008	174	238	412
10030101	244	329	573
10030102	168	336	504
10030103	70	371	441
10030104	66	305	371
10030105	64	100	164
10030201	30	109	139
10030202	42	76	118
10030203	226	244	470
10030204	11	98	109
10030205	23	451	474
10040101	147	223	370
10040102	3	160	163
10040103	112	307	419
10040104	249	723	972
10040105	71	178	249
10040106	58	146	204
10040201	744	5	749
10040202	390	7	397
10040203	27	139	166
10040204	47	237	284
10040205	371	6	377
10050001	0	55	55
10050002	0	121	121
10050003	0	13	13
10050004	164	390	554
10050005	22	99	121
10050006	67	32	99
10050007	8	19	27
10050008	26	62	88
10050009	16	120	136
10050010	49	115	164
10050011	4	68	72
10050012	90	190	280
10050013	5	32	37
10050014	0	301	301
10050015	32	87	119
10050016	36	74	110
10060001	82	281	363
10060002	357	308	665
10060003	250	13	263
10060004	118	6	124
10060005	62	213	275
10060006	423	27	450
10060007	63	4	67
10070001	9	113	122
10070002	90	585	675
10070003	112	53	165
10070004	77	660	737
10070005	212	101	313
10070006	9	447	456
10070007	23	423	446
10070008	47	97	144
10080010	142	13	155
10080014	13	50	63
10080015	354	34	388
10080016	91	106	197
10090101	91	85	176
10090102	628	76	704
10090207	98	90	188
10090208	107	61	168
10090209	203	187	390
10090210	87	80	167
10100001	212	640	852
10100002	38	87	125
10100003	38	169	207
10100004	199	453	652
10100005	241	173	414
10110201	39	544	583
10110202	14	300	314
10110203	5	17	22
10110204	30	128	158
17010101	17	23	40
17010102	3	13	16
17010103	0	10	10
17010104	0	2	2
17010105	0	2	2
17010201	18	287	305
17010202	234	23	257
17010203	4	276	280
17010204	3	33	36
17010205	115	368	483
17010206	34	15	49
17010207	35	17	52
17010208	108	47	155
17010209	0	166	166
17010210	21	9	30
17010211	15	170	185
17010212	60	342	402
17010213	98	58	156

TABLE A-6. POWER GENERATION: 1980 WATER USE IN MONTANA BY HYDROLOGIC UNIT

Hydrologic Unit[1]	Thermoelectric Water Withdrawn (af)	Thermoelectric Water Consumed (af)	Thermoelectric Power Generated (MWh)	Hydroelectric Water Used (af)	Hydroelectric Power Generated (MWh)
10020007	0	0	0	949,212	70,000
10030101	0	0	0	9,561,684	851,000
10030102	0	0	0	19,182,834	1,506,000
10040104	0	0	0	7,570,134	1,258,000
10070004	52,622	2,210	1,287,000	0	0
10070005	0	0	0	62,832	54,000
10080010	0	0	0	2,316,930	875,000
10100001	7,091	7,091	4,289,000	0	0
10100004	34,349	0	330,000	0	0
17010101	12,836	0	25,000	6,728,634	1,895,000
17010202	0	0	0	14,586	4,000
17010203	0	0	0	832,524	17,000
17010208	0	0	0	4,488	2,000
17010209	0	0	0	1,534,896	609,000
17010211	0	0	0	142,494	28,000
17010212	0	0	0	5,884,890	912,000
17010213	0	0	0	19,197,420	1,995,000

[1]For hydrologic units not listed, water use equals zero.



APPENDIX B

METHODS FOR ESTIMATING WATER USE

IRRIGATION

Estimates of water withdrawn and consumed for irrigation by county were derived from the following equations:

Number of Irrigated Acres	x	Crop Irrigation Requirement	=	Water Consumed
Water Consumed	÷	Overall Irrigation Efficiency	=	Water Withdrawn

The following shows how each variable--irrigated acres, crop irrigation requirement, and overall irrigation efficiency--was calculated.

Irrigated Acres. The number of acres irrigated during 1980 in each county was assumed to be the total of the number of acres under irrigation before 1973, which are listed in DNRC's computerized land classification system, and the number of irrigated acres developed after 1973, as reflected by DNRC water right permits. Permit data for the ten years beginning in 1973 and ending in 1983 were used to estimate irrigation development from 1973 to 1980, since these data were readily available. The use of the 1973-83 permit data should not affect the reliability of the estimate of 1980 water use, because little new land came under irrigation between 1980 and 1983.

This method of determining total irrigated acreage probably results in an overestimate of actual irrigated acreage for 1980. The pre-1973 and post-1973 irrigated land data are based on land with irrigation systems either in place or about to be put in place. Using this data to estimate actual irrigated land results in an overestimate because in any given year, some of these lands are not irrigated due to such factors as market conditions, ownership changes, or water availability. In addition, some irrigated land may have been counted twice because certain landowners may have obtained water use permits (counted as post-1973 lands) for land that was irrigated prior to 1973.

The total irrigated acreage estimate for each county was separated into lands using surface water and those using ground water by using the 1982 Census of Agriculture (USDC 1984). This division was made because surface-water-supplied lands differ from ground-water-supplied lands in the amount of water withdrawn. Generally, ground-water-supplied irrigation systems are more efficient than surface-supplied systems, because the closed pipelines from the wells prevent seepage loss. The Census of Agriculture (COA) estimates the number of irrigated acres in each county and the number irrigated from ground water. Total ground-water-irrigated acres were subtracted from the total number of irrigated acres to obtain total COA surface-water-irrigated land. From these data the percentage of land irrigated by surface or ground water was calculated. The percentages were multiplied by the DNRC estimate of total irrigated land for each county to obtain the number of surface- and ground-water irrigated acres used in this report. These equations are:

Total Irrigated Acres (DNRC)[1]	x	Percentage of Acres Irrigated by Ground Water (COA)	=	Total Acres Irrigated by Ground Water (DNRC)
Total Irrigated Acres (DNRC)	x	Percentage of Acres Irrigated by Surface Water (COA)	=	Total Acres Irrigated by Surface Water (DNRC)

All ground-water-supplied land was assumed to be under full-service irrigation. Land irrigated with surface water was designated as either full- or partial-service based on data reported in the Soil Conservation Service (SCS) Salvage Report (USDA 1978). This was necessary because irrigation of partial- and full-service lands results in the withdrawal and consumption of different amounts of water. The Salvage Report presents estimates of total irrigated acres and total partial-service-irrigated acres for each county. The total irrigated acres listed in the

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[1]DNRC used its estimates for irrigated acres instead of those listed in the COA because it believes they are the most accurate available.

Salvage Report were assumed to include only surface-irrigated land (USDA 1985). The report was used to determine the percentage of land in each county under partial-service or full-service irrigation. DNRC's estimate of surface-irrigated land was then multiplied by these percentages for each county as follows:

Total Acres Irrigated by Surface Water (DNRC)	x	Percentage of Acres Under Partial Service (SCS)	=	Total Acres Under Partial-Service Irrigation by Surface Water (DNRC)
Total Acres Irrigated by Surface Water (DNRC)	x	Percentage of Acres Under Full Service (SCS)	=	Total Acres Under Full-Service Irrigation by Surface Water (DNRC)

Crop Irrigation Requirements. Full-service crop irrigation requirement (CIR) is the quantity of water required through irrigation to meet a crop's water needs. It is dependent on crop type and local weather conditions. Certain crops require more water than others to mature. In addition, CIR is higher in dry areas than in areas receiving more precipitation. The SCS Irrigation Guide (USDA 1972) provides CIR by zones of similar climatic conditions for each crop grown in Montana. It also contains a map showing the five climatic zones identified in the state. In each county, an overall CIR was calculated by determining the percentage of the total irrigated lands in the county that each crop occupies, and the percentage of the county in each climatic zone. The following formulas show how CIR was calculated for a county with two crop types and two climatic zones.

(% of Crop A in County	x	Crop A Zone 1 CIR)	+	(% of Crop B in County	x	Crop B Zone 1 CIR)	=	Climatic Zone 1 CIR
(% of Crop A in County	x	Crop A Zone 2 CIR)	+	(% of Crop B in County	x	Crop B Zone 2 CIR)	=	Climatic Zone 2 CIR
(% of County in Zone 1	x	Climatic Zone 1 CIR)	+	(% of County in Zone 2	x	Climatic Zone 2 CIR)	=	Overall County CIR

For counties with more than two major crops or climatic zones, this formula was expanded. The 1978 Census of Agriculture (USDC 1978) was used to calculate the percentage area encompassed by each irrigated crop type grown in a county. Mountainous areas shown on the SCS Irrigation Guide climatic zone map were not included in the total area of a county when determining the percentage area of each zone, because mountains have little or no irrigation. Partial service CIR estimates for each county came from the SCS (USDA 1978).

Overall Irrigation Efficiency. The overall irrigation efficiencies for lands served by surface water were obtained from the SCS Salvage Report (USDA 1978) for surface-water irrigation. Based on SCS (1985) and USGS (1985) information, overall irrigation efficiency for full-service lands supplied from ground water was assumed to be 74 percent.

Irrigation by USGS Hydrologic Unit. The formulas used to determine county water use were also used to estimate water use by USGS hydrologic unit, but with some adjustments. Irrigated acreage in each USGS hydrologic unit was found by identifying land developed for irrigation before 1973 on maps that show the USGS hydrologic unit boundaries. Total irrigated acreage in a USGS hydrologic unit was obtained by adding the pre-1973 lands to the post-1973 irrigated acreage, which are recorded on DNRC's computerized water right permits system.

The post-1973 lands are listed by DNRC hydrologic basin, and had to be adjusted to reflect USGS hydrologic unit boundaries. This adjustment was accomplished by assuming that irrigated acreage in a DNRC hydrologic basin was distributed uniformly. For each DNRC basin that lies entirely or partially within a USGS unit, the percentage of its total area within the USGS unit was calculated. Total post-1973 irrigated acreage in the DNRC basins was then multiplied by the appropriate percentage to derive the irrigated acreage that basin contains within the USGS hydrologic unit. These acreages were then summed for each DNRC basin to produce the total post-1973 acreage in the USGS hydrologic unit.

A problem with the assumption that irrigated lands were spread uniformly throughout a DNRC basin occurred when one of two or more USGS units, located within a single DNRC unit, contained a majority of the irrigated land listed in the permits. By assuming a uniform distribution in the DNRC basin, the irrigated land was spread evenly over the USGS basins resulting in an underestimation of irrigated acreage in one USGS unit and a corresponding overestimation in the other units. This problem occurred in only a few cases.

Irrigated land lying in the USGS hydrologic units was also separated into ground- or surface-water supplied lands to account for differences in water use. This was done by adjusting the percentages used to derive county estimates of lands supplied from either surface- or ground-water sources. This adjustment was accomplished by overlaying county boundaries on USGS hydrologic unit maps. The area of each county located in a USGS unit was measured. From this, the percentage of the USGS unit that the county comprises was calculated, and used in the following formulas.

$$\text{Total Irrigated Acres in USGS Hydrologic Unit} \times \sum_{i=1}^{n*} \left(\text{Percentage of USGS Unit Within the County} \times \text{Percentage of Groundwater Irrigated Acres in a County (COA)} \right) = \text{Total Acres Irrigated by Ground Water in USGS Hydrologic Basin}$$

$$\text{Total Irrigated Acres in USGS Hydrologic Unit} \times \sum_{i=1}^{n*} \left(\text{Percentage of USGS Unit Within the County} \times \text{Percentage of Surface Water Irrigated Acres in a County (COA)} \right) = \text{Total Acres Irrigated by Surface Water in USGS Hydrologic Unit}$$

*n = number of counties located within a USGS hydrologic unit basin.

In addition, surface-supplied lands were separated into partial- or full-service irrigated lands in each USGS hydrologic units. The above formulas were used to do this, except that the total irrigated acres in a USGS hydrologic unit was replaced by total acres irrigated by surface water, and the percentage of ground- or surface-water irrigated acres in a county was replaced by the percentage of partial- or full-service irrigated acres in a county (from USDA 1978).

Crop irrigation requirements and overall efficiencies for each county were converted to USGS hydrologic units in a similar manner. These variables were then used to determine the water withdrawn and consumed in each USGS basin.

MUNICIPAL SYSTEMS

A survey was conducted to determine the amount of water withdrawn for municipal systems in Montana by county and USGS hydrologic basin. Operators of 540 municipal systems were sent questionnaires and more than 60 percent responded, some with metered information and others with estimates. Nonrespondents were primarily operators of smaller systems without meters. Water withdrawn by these small municipal systems was based on a per capita use of 138 gpd which is a statewide average developed from the survey. It was assumed that 37 percent of the water withdrawn by municipal systems is consumed (USGS 1980, DNRC 1975). The following formulas show how water use by nonrespondents was calculated:

Population Served	x	138 Gallons Per Day	x	366 Days Per Year	=	Water Withdrawn

Water Withdrawn	x	37%	=	Water Consumed

RURAL DOMESTIC

Rural domestic water use was calculated in the following way:

Rural Population	x	78 Gallons per day	x	366 days per year	=	Rural Withdrawn and Consumed

The number of rural domestic users in each county was calculated by subtracting the number of people served by municipal systems from the total county population as determined by the Census Bureau (USDC 1980). The number of rural users was multiplied by the average per capita use of 78 gpd which was based on statistics from municipal systems serving less than 55 users. All water withdrawn for rural domestic use was considered consumed (DNRC 1975).

Total rural domestic water use was separated into water from surface and ground sources. The post-1973 water right permits list water use by source for each county. The percentage of water use from each source was calculated from the permit data and then multiplied by total rural water use to estimate surface water and ground water withdrawals as follows.

Total Water Consumed	x	Percentage of Ground Water Use in the County	=	Volume of Ground Water Use
Total Water Consumed	x	Percentage of Surface Water Use in the County	=	Volume of Surface Water Use

Water use by USGS hydrologic unit was estimated by assuming the rural population is uniformly distributed over each county. The percentage of a county's area lying within a basin was multiplied by the total county rural population. This process was repeated for each county in the basin, and then the county results were totaled to obtain a basin population. The assumption of uniformity may result in populations being overestimated in some USGS basins with a corresponding underestimate in others.

SELF-SUPPLIED INDUSTRY

A statewide survey was conducted in 1980 to estimate water use for self-supplied industries by county and USGS hydrologic unit. Six hundred twelve manufacturers were found in the Directory of Montana Manufacturers (Montana Department of Administration 1981), all of whom were sent questionnaires. Three hundred six responses were received.

To estimate the water use of nonrespondents, it was assumed that the number of employees was directly related to the firm's water use. Water use was obtained by separating the responding manufacturers into 25 categories of production based on the Standard Industrial Classification Manual (Office of Management and Budget 1972). Based on survey responses, the average water use per employee was calculated for each of the 25 categories. This information was then used in the following formula.

Number of People Employed by Non-respondents in a Category	x	Per Capita Use in that Industrial Category	=	Nonrespondent Industrial Water Use for that Category

It was assumed that 15 percent of the withdrawn water was consumed (DNRC 1975).

For nonrespondents, the source of water, either from the ground or surface, was determined from the 1974 Industrial Water Use Survey (Montana Department of Highways 1979).

LIVESTOCK

Estimates of water withdrawals for livestock use were calculated by multiplying county livestock populations (Montana Department of Agriculture 1982) by average per capita livestock water requirements. One hundred percent of the withdrawals were assumed to be consumed.

Total county water use for livestock was separated into surface- and ground-supplied water by using the post-1973 water right permits. The permits list livestock water use by source of supply, and were used to calculate the percentage supplied by either ground water or surface water. These percentages were then multiplied by total county livestock water use to estimate water use from surface and ground supplies.

To estimate water use by USGS hydrologic unit, it was assumed that livestock populations were uniformly distributed over a county. The percentage of a county lying within a USGS unit was then multiplied by the total number of animals in a county. This process was repeated for all counties within a basin, and the results combined to derive a basin total. The resulting livestock numbers were then multiplied by the requirements listed in table B-1 to estimate water use by USGS hydrologic unit.

TABLE B-1. LIVESTOCK WATER REQUIREMENTS

	Gallons per Head per Day
Dairy Cattle	23.00
Beef Cattle	15.00
Hogs	5.00
Sheep	3.00
Chickens	.05

THERMOELECTRIC AND HYDROELECTRIC POWER GENERATION

Estimates of water use in 1980 for thermoelectric and hydroelectric power generation came from a survey of all power producers in the state. The survey had a 100 percent response.

RESERVOIR EVAPORATION

The average annual evaporation from reservoirs in Montana, with the exception of the largest size class, was calculated in the following way:

Average Reservoir Surface Area by Size Class	x	Number of Reservoirs in the Size Class	=	Total Reservoir Surface Area by Size Class
Total Surface Area by Size Class	x	Statewide Average Annual Evaporation Rate	=	Annual Evaporation by Size Class

For this analysis, reservoirs were divided into three classes based on size. The first size class comprises the state's eight largest reservoirs: Fort Peck, Canyon Ferry, Flathead Lake, Hungry Horse, Bighorn, Lake Elwell, Lake Koocanusa, and Noxon Rapids. Evaporation for the eight reservoirs was calculated individually using local climatic data.

The second class meets the U.S. Army Corps of Engineers (USCE) Inventory of Dams criteria. These criteria are listed in footnote 2 of table 9 in the text. Although the state's eight largest reservoirs also meet the USCE criteria, they were not included in the second class because their large size would result in an overestimate of average reservoir surface area. The third class consists of reservoirs not meeting the USCE criteria. The number of reservoirs and their average surface area was obtained from DNRC (1984).

A statewide average annual evaporation rate of 3.37 feet per acre was calculated based on regional average evaporation rates (DNRC 1976). This average surface evaporation rate was used in the formula above to determine the annual evaporation for medium and small reservoirs.

Water Resources Division
1520 East Sixth Avenue
Helena, Montana 59620

Montana Department of Natural Resources and Conservation

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